DREDGED MATERIAL RESEARCH PROGRAM

TECHNICAL REPORT D-78-1

USE OF DREDGED MATERIAL ISLANDS BY COLONIAL SEABIRDS AND WADING BIRDS IN NEW JERSEY

by

Francine G. Buckley, Cheryl A. McCaffrey
Manomet Bird Observatory
Manomet, Mass. 02345

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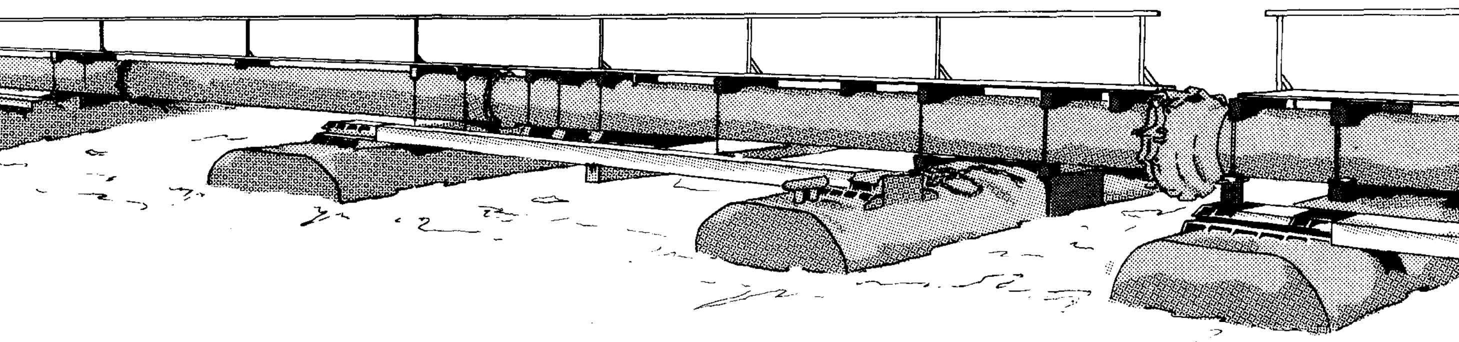

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1. The technical report transmitted herewith represents the results of Work Unit 4F01D, regarding vegetation succession and wildlife use of dredged material islands in New Jersey. This work unit was conducted as part of Task 4F (Island Habitat Development) of the Corps of Engineers' Dredged Material Research Program (DMRP). Task 4F was part of the Habitat Development Project of the DMRP and had as its objective the investigation, evaluation, and testing of methodologies for habitat creation and management on dredged material islands.

2. Island habitat development was studied by the DMRP throughout the United States through an evaluation of vegetation succession and animal use of existing dredged material islands. The most significant wildlife aspect of these islands is their use by colonial nesting sea and wading birds (such as gulls, terns, egrets, herons, ibises, and pelicans). This wildlife resource, although generally inadvertently created, presents a significant opportunity for habitat management and development that is consonant with continued dredged material disposal.

3. In the study reported herein, dredged material islands along the Intracoastal Waterway of New Jersey were surveyed and 20 were examined in detail. It was found that waterbird habitat is quite scarce in New Jersey and that 75 percent of arboreal and 20 percent of ground-nesting species were using dredged material for nesting (more than 115,000 adults). Many ground-nesting waterbirds that usually nest on dredged material islands were nesting in the marsh drift with mixed success due to limited habitat.

4. From a local perspective, this study will be of direct value in managing and developing dredged material island habitats in New Jersey. A national perspective is presented in a report entitled "Development and Management of Avian Habitat on Dredged Material Islands" (4F03), which synthesizes island habitat research in New Jersey, the Great Lakes (4F01A), North Carolina (4F02), Florida (4F01C), Texas (4F01B), the Pacific Northwest (4F01E), and the Upper Mississippi River (4F01F).

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The use of dredged material islands by colonial nesting seabirds and wading birds in New Jersey was examined in five major phases. The first located dredged material islands from Manasquan to Cape May Inlets, NJ; the second recorded the past history of all colonial nesting seabirds and wading birds in New Jersey; the third recorded the vegetation patterns and succession on 21 dredged material islands selected for intensive study; the fourth recorded the distribution in

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1977 of colonial seabirds and wading birds in the study area and their utilization of dredged material islands; and the fifth documented those factors influencing the use and selection of dredged material islands by birds in 1977.

Plant communities were placed into 15 categories. The most important ones for birds on the dredged material study islands were bare, common reed, reed-shrub, shrub, shrub-forest, shrub-dense grassland, and dense grassland. More than 52,000 pairs of colonial seabirds and wading birds of 16 species nested in the study area. Their use of dredged material islands by percent of their total population ranged from zero (Forster's terns) to 71 percent (herons). No statistically significant vegetation differences were found between the 11 bird (colony) and 10 vegetation (non-colony) study islands, leading to the conclusion that other factors, notably microtopography, past history of colony success, and freedom from disturbance by quadruped predators and humans, may be the most important in determining island use by birds, given certain minimal habitat requirements.

Nineteen management recommendations for dredged material islands are stated, including annual wildlife surveys, careful monitoring of contractor performance, attention to record keeping, preservation of alternative colony sites, rotational use and management of dredged material islands, proportional habitat creation and management, and protection of all islands with bird colonies.

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SUMMARY

This report summarizes the results of investigations of the distribution of colonial seabirds and wading birds on New Jersey dredged material islands, of vegetation distribution and succession on dredged material islands, and of the interactions of vegetation and birds on dredged material islands.

Investigations were divided into five phases concerned with: (a) the location of dredged material islands along the 190.7-km length of the New Jersey Intracoastal Waterway, between Cape May Inlet and Manasquan Inlet; (b) the past history of colonially nesting seabirds and wading birds in New Jersey; (c) vegetation patterns and succession on 21 dredged material study islands; (d) the distribution of colonial seabirds and wading birds on dredged material islands along the New Jersey Intracoastal Waterway; and (e) the documentation of factors influencing the use and selection of dredged material islands as colony sites by colonially nesting species.

In New Jersey, barrier beach and salt marsh habitat left undisturbed and available to nesting birds has decreased drastically since the early 1900's. The salt marshes have been severely altered by dredging, ditching, and filling operations. Despite these alterations most of the colonial nesting species studied were nesting in considerable numbers on the islands and salt marshes behind the barrier islands.

Dredged material islands currently provide many of the colony sites for waterbird species formerly nesting on barrier islands. The specific study area contains nearly 200 islands or sites known or suspected to be of dredged material origin. Twenty-one dredged material islands were selected for detailed study of their vegetation and successional patterns. Eleven supported colonial bird colonies: six heronries, five gull colonies, two least tern colonies, and one common tern colony harboring a few pairs of black skimmers. Ten islands had no colonial nesting birds. The study islands ranged from high-domed and circular, through irregularly shaped and flat, to diked.

Plant seral stages, ages, major plant species, colonial seabird

and/or wading bird populations and island characteristics were recorded. Aerial photographs, bird colony maps, and vegetation maps are presented for each study site.

Vegetation field studies were conducted using four methods: (a) photointerpretation of false-color, infrared aerial imagery, (b) on-site vegetation sampling, (c) general field reconnaissance, and (d) calculation of areas covered by various vegetation mapping units. Vegetation maps were prepared for each study island. One hundred different plant specimens collected on dredged material islands were sent to the U.S. Army Engineer Waterways Experiment Station (WES) for preservation. Soil samples collected on each dredged material study island were also sent to WES for analysis.

The vegetation communities and seral stages found on the dredged material study islands were summarized. Species present were indicative of low tidal marsh, high tidal marsh, grassland, shrub-thicket, and dune woodland communities. Vegetation communities indicative of early, mid, and late seral stages of plant succession are described. Their distribution on the dredged material study islands is also discussed. Plant communities or species on study islands were found to be typical of southern New Jersey.

Colonial nesting bird populations were surveyed and censused using a Model 206B, Bell Jet Ranger helicopter. Colony sites on islands, salt marshes, and barrier beach islands 1.6 km to each side of the New Jersey Intracoastal Waterway were located. Breeding populations at smaller colonies were determined by actual count and by section counting at larger colonies.

Sixteen colonial waterbird species were found nesting in the specific study area: little blue heron, cattle egret, great egret, snowy egret, Louisiana heron, black-crowned night heron, yellow-crowned night heron, glossy ibis, great black-backed gull, herring gull, laughing gull, gull-billed tern, Forster's tern, common tern, least tern, and black skimmer. Forster's tern was the only species not associated in any way with dredged material. Laughing gull and gull-billed tern nested on some salt marsh sites that may have been of dredged material origin, although they were predominantly natural salt marsh nesters. A total of 117 separate colony sites were located. Common terns and herring gulls were the most widespread species, occurring at 52 and 40 locations, respectively. Least terns and black skimmers, both endangered species in New Jersey, were found at 15 and 14 sites, respectively. A total of 32 wading bird colonies were present, many of them on older, inactive dredged material sites.

A total of 52,205 pairs of nesting colonial seabirds and wading birds was counted. Laughing gulls (35,241 pairs) were the most numerous and gull-billed terns (18 pairs) were the least numerous. Common terns and herring gulls had similar populations with 4667 and 4202 pairs, respectively. Snowy egrets (2,094 pairs) and glossy ibises (1,543 pairs) were the most numerous of the 5582 pairs of wading birds counted.

Analysis of habitat data was confined to examination of the general colony habitat and comparisons of population and colony site type distributions. Overlay maps of bird colonies and vegetation were made of each study site. Comparisons were made between vegetation communities on study islands with and without bird colonies.

Vegetation maps show 15 vegetation communities. Adjacent tidal flats were also noted as was the distribution of salt marsh drift vegetation on most of the study islands. Frequency, cover, and height data were obtained on various study islands, a "visibility index" was derived from combined cover and height values, the area occupied on each island was computed, and the presence or absence of plant communities across all islands was recorded. Data on island size, dredged material deposit size, and probable ages of study islands were compared between the vegetation and bird study islands.

The importance of dredged material islands to colonial seabird and wading bird populations in New Jersey was determined with the importance to individual species considered. The islands were of the greatest importance to wading birds, followed by great black-backed gulls, and herring gulls. Least terns also had a major portion of their population on dredged material. Common terns were found nesting mostly in salt marshes, probably forced there from more traditional barrier island sites by development and their disturbance. Common terns seem to be unable to compete successfully with humans and herring gulls for the decreasing number of suitable sandy sites left in New Jersey. Black skimmers have nested in some numbers on dredged material sites in New Jersey but there is a scarcity of suitable bare sand sites for their colonies.

Avifaunal effects upon vegetation are briefly discussed; fecal enrichment on the colony nest site, mechanical destruction of vegetation, and seed transport were specifically considered.

Conclusions drawn from this study included recognition of the following needs: (a) a complete inventory of dredged material islands in New Jersey; (b) additional research on plant patterns and succession, taking into account such factors as island microtopography, water table levels, salinity factors in soil and water, salt spray, and tidal inundation; (c) other research of variables not programmed for this study such as previous colony nesting success, microtopography of the colony site, disturbance by humans, disturbance by quadruped predators, and adjacent beach development which, given certain minimum habitat requirements, are probably the most critical factors in colony site selection by colonial seabirds and wading birds; and (d) management of dredged material islands as a wildlife resource.

Nineteen management recommendations are made pertaining to the general management of dredged material islands as a wildlife resource, as well as specific management procedures for colonial seabirds and wading birds in New Jersey. They concern: (a) an inventory of dredged material islands; (b) wildlife surveys of dredged material islands; (c) the timing of dredged material deposition; (d) contractor waterbird surveys; (e) record keeping; (f) integration of inlet dredging with Intracoastal Waterway dredging; (g) needed research; (j) colonial waterbird surveys; (k) deposition on colony sites; (l) habitat surveys; (m) alternative colony sites; (n) rotational island management; (o) wading bird management; (p) proportional habitat representation; (q) island diking; (r) maintenance of bare sand habitat; and (s) protection.

Management recommendations offered herein do not constitute a complete management program for colonial seabirds and wading birds and dredged material islands. Rather, it is hoped that they will provide a starting point for further investigation and cooperation between all groups whose responsibilities include the management of dredged material islands and their avian wildlife resources.

PREFACE

The work described in this report was performed under Contract No. DACW 39-76-C-0166, titled "Use of Dredged Material Islands by Colonial Seabirds and Wading Birds in New Jersey," between Manomet Bird Observatory, Manomet, Massachusetts, and the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi. The study was conducted as part of the Office, Chief of Engineers Dredged Material Research Program (DMRP). The DMRP is sponsored by the Office, Chief of Engineers, and is assigned to WES under the Environmental Laboratory (EL).

In the DMRP, the study was part of the Habitat Development Project (HDP) and designed to determine the national significance of dredged material islands to colonially nesting seabirds and wading birds, and to develop a management program for dredged material islands as a manageable wildlife resource.

Field work and the initial report was prepared by Ms. Francine G. Buckley and Ms. Cheryl McCaffrey of Manomet Bird Observatory. Ms. Mary C. Landin, WES, was Contract Manager and contributed some figures and portions of text to the final manuscript, as well as located the dredged material islands in New Jersey. Dr. Robert F. Soots, Jr., WES, served as technical adviser. Ms. Landin, Dr. Soots, and Ms. Mary K. Vincent provided technical review.

The study was conducted under the general supervision of the following EL personnel: Dr. H. K. Smith, HDP Manager; Dr. Roger T. Saucier, Special Assistant for Dredged Material Research; and Dr. John Harrison, Chief, EL. COL John Cannon, CE, was Commander and Director, WES. Mr. F. R. Brown was Technical Director, WES.

Many persons provided expertise and help and their contributions are gratefully acknowledged: Dr. Joanna Burger, Rutgers University, provided access to unpublished and published field data as well as many hours of useful discussion about the many facets of this study. Mr. Richard Kane, Director of the Wildlife Research unit, New Jersey Audubon Society (NJAS), made essential resources available and gave access to the NJAS colonial waterbird survey results in both 1976 and

1977. Mr. Fred Lesser, Director, Ocean County, NJ, Mosquito Control Commission, contributed information about dredged material islands in New Jersey, bird distribution in Ocean County, and provided field assistance. Dr. Joseph Shisler, Rutgers University, also supplied information about Ocean County avifauna and dredged material islands. Messrs. William Shoemaker and Robert Mangold, New Jersey Division of Fish, Game, and Shellfisheries, and Ms. Joan Galli, New Jersey State Non-Game Biologist, provided useful discussion and information about the New Jersey State Endangered Species Program and additional data on colonial waterbirds in New Jersey. Ms. M. Pokras, Stockton State College, gave useful information on the Least Tern Protection Program in New Jersey. Messrs. Michael Bartlett and Gaylord Inman, U. S. Fish and Wildlife Service, were helpful with information about Brigantine National Wildlife Refuge. Mr. Bartlett also furnished information aobut dredging operations in New Jersey. Mr. Johan Wiese and Dr. R. Michael Erwin also contributed to this report through several useful discussions about colonial waterbirds in New Jersey and Delaware. Dr. Paul Godfrey, University of Massachusetts-Amherst, provided technical advice for the vegetation studies on this project. Dr. Harry E. Ahles, University of Massachusetts-Amherst, identified several and verified all plant specimens collected in New Jersey for this study. Mr. Roger Clapp, Bird Section, National Bird and Mammal Laboratory, provided access to the resources of the National Museum of Natural History throughout this study and provided assistance with avian literature. Mr. Robert Anderson, Norfolk, Virginia, assisted the principal investigator in the field, and Mr. N. Farante, Ronson Airways, Trenton, NJ, was the helicopter pilot. Ulla Soforenko, Mapmakers, Inc., drafted the bird overlay maps and final dredged material island and bird colony distribution maps. Mrs. Mary Duarte, Aid, Inc., typed the Phase III report and first draft final report. Dr. P. A. Buckley, National Park Service and Rutgers University, provided assistance with historical information on colonial waterbirds in New Jersey.

Administrative management for the Manomet Bird Observatory was provided by Mr. Joseph A. Hager, Managing Trustee, Ms. Kathleen S. Anderson, Executive Director, and Mr. Kenneth A. Youngstrom, Director of Contract Operations.

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USE OF DREDGED MATERIAL ISLANDS BY COLONIAL SEABIRDS AND WADING BIRDS IN NEW JERSEY

PART I: INTRODUCTION

Background and Purpose of Study

1. This report was prepared under the sponsorship of the U.S. Army Corps of Engineers Dredged Material Research Program (DMRP). It is one of several studies, conducted on a nationwide basis, to assess the potential value of dredged material islands. The purpose of this study was to determine (a) the use of dredged material islands in New Jersey by colonial nesting seabirds and wading birds, (b) the succession of vegetation on dredged material islands used by these colonial nesting species, and (c) any relationships between succession of vegetation and colonial nesting species. The results of this study along with several similar studies in other parts of the United States will be used to provide information useful to the future creation, development, and management of dredged material islands as possible areas for wildlife habitat development.

2. The New Jersey study was divided into five phases: Phase I was concerned with the location of dredged material islands within the specific study area which coincided with the length (190.7 km) of the New Jersey Intracoastal Waterway from Cape May Inlet in the south to Manasquan Inlet in the North (Figure 1); Phase II was concerned with the past history of colonial nesting seabird and wading bird species in New Jersey, and data are presented in detail in Appendix A; Phase III was concerned with determining vegetation patterns and succession on 21 dredged material islands chosen for detailed analysis and these results are presented in Appendix B; Phase IV was concerned with the

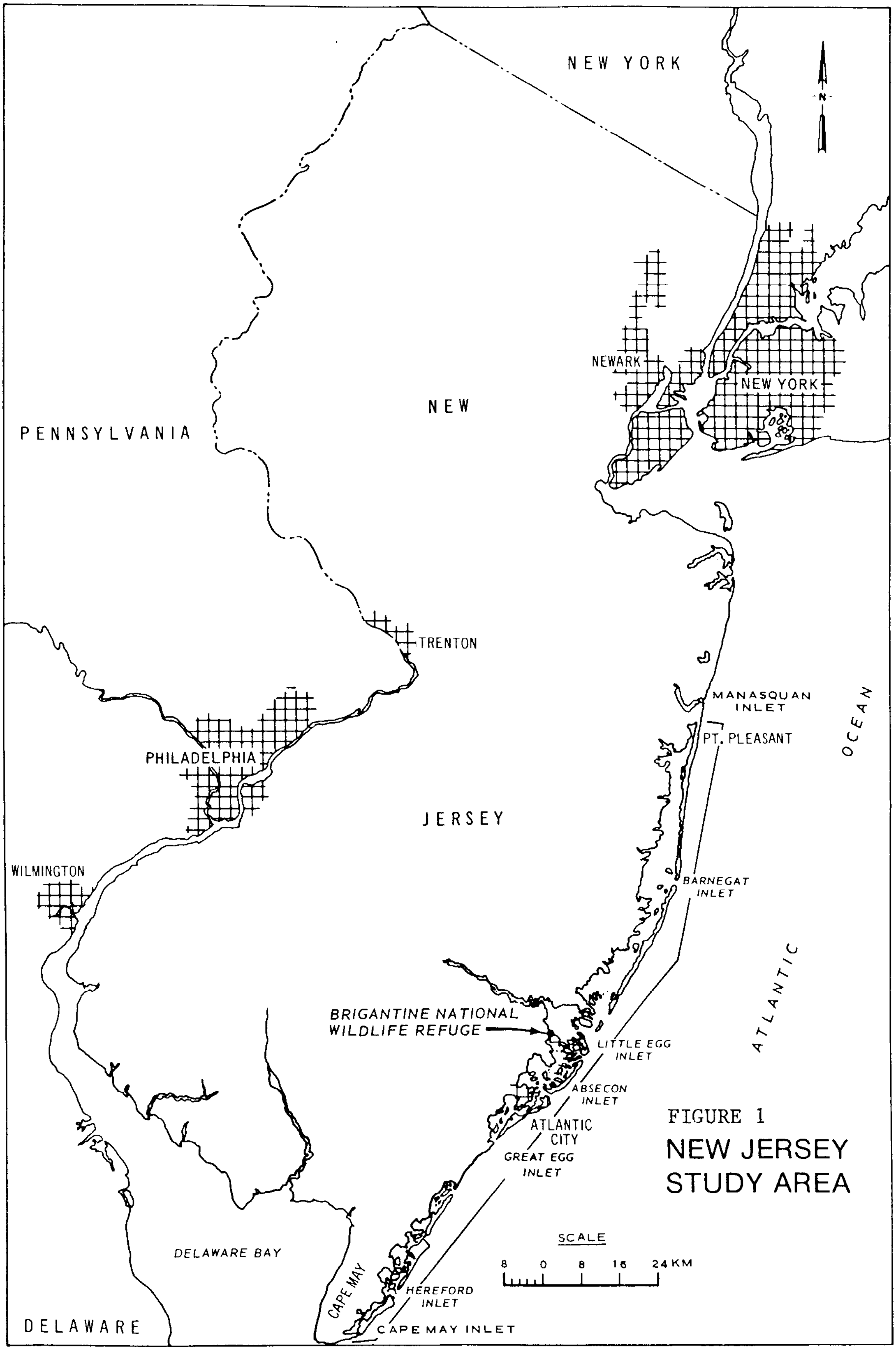

FIGURE 1

NEW JERSEY STUDY AREA

use of dredged material islands by colonial nesting birds in New Jersey during the 1977 breeding season; and Phase V was concerned with documentation of factors influencing the use and selection of dredged material islands as nest sites by colonially nesting species.

Literature Review

3. Scientific literature pertaining to the use of dredged material islands by colonial nesting seabirds and wading birds in New Jersey is relatively scarce. Stone (1937) presented one of the earliest references to bird use of dredged material sites in New Jersey. In the early 1970's Downing (1973), Fisk (1974) and Buckley and Buckley (1974) noted use of dredged material areas for nesting sites in the New Jersey area. More recently, Kane and Farrar (1976, 1977) also noted whether or not colonies were located on "spoil" sites in the colonial bird surveys sponsored by the New Jersey Audubon Society and U.S. Fish and Wildlife Service.

4. In 1928 Stone (1937) observed that common terns, black skimmers, and least terns were utilizing areas in the meadows (salt marshes) behind the barrier islands where sand dredged from the Intracoastal Waterway channel had been deposited. Stone also referred to black skimmers nesting behind Brigantine on a sand flat on the meadows resulting from "dredging out the channel." In 1925, Charles Urner wrote to Stone describing a "high sand island created by the dredging of the channel" north of Little Beach Island near Brant Beach, where he had located a pair of nesting black skimmers. This colony grew and was present until at least 1937 with up to 75 pairs breeding there. Stone also noted that in addition to sand placed upon the salt marshes being utilized as nest sites, low marsh islands "partly covered by dredgings of sand from the channel" were also being used by common terns for nest sites.

5. Least terns that require bare sand, gravel, or cobble for nesting were recognized by Stone as being in serious trouble in New Jersey because of the loss of beachfront colony sites from heavy

development in the 1920's, combined with the species' extirpation as a breeding species in New Jersey during slaughters by the millinery trade of the late 1800's. Stone's words written in 1937 are pertinent today...

> Unfortunately the status of the least tern is rather precarious since the beaches which are its true home are almost entirely taken over by building operations and resort developments while people and dogs constantly disturb the birds during the early summer when they should be free from persecution. Were it not for the recent sand flats left by the dredges in deepening the inland waterway they would probably ere now have again taken their departure. Whether they will permanently establish themselves on these more or less artificial nesting grounds remains to be seen.

Unfortunately, least terns and black skimmers are today both on the New Jersey endangered species list. Both species nest on frequently disturbed dredged material sites that interfere with these species' successful production of young.

6. The utilization of dredged material islands by wading birds (herons, egrets, ibises) in New Jersey has not been specifically discussed in the scientific literature except for brief mention of certain colonies as being located on "spoil islands" by Burger (1978) and Kane and Farrar (1976).

7. The importance of dredged material islands in providing comparatively undisturbed nesting habitat for colonially nesting seabirds and wading birds had been generally overlooked until the late 1960's and early 1970's, when several researchers independently began investigating the use of these sites as a wildlife resource. Preliminary nesting bird surveys of least terns by Fisk (1974) and Downing (1973) also helped to focus interest on dredged material sites as potential nesting habitat along the Atlantic coast. Florida (Carlson 1972), Texas (Barnes 1971, McMurry 1971, Simersky 1971), North Carolina (Soots and Parnell 1975a, 1975b; Buckley and Buckley 1973, 1974, 1977), Virginia (Buckley and Buckley 1974, 1977), and New York (Buckley and Buckley 1974, 1977) have all been the sites of some investigation into the use of dredged material islands by colonial nesting waterbirds. The potential of dredged material islands as sites that could be managed to provide desirable breeding habitat for colonial nesting species in areas

where natural habitat is no longer available or is becoming reduced through human activities, has also been studied and discussed in the literature by Soots and Parnell (1975a, 1975b) and Buckley and Buckley (1974, 1976, 1977).

PART II: MATERIALS AND METHODS

Description of the Study Area

8. New Jersey is the fifth smallest state, having a land area of only 12,084 km^2. It is 267 km long and only 91.7 km at its widest point. The 1970 census figures indicated that New Jersey had a population of over seven million people giving it a density of over 1600 persons per km^2. In addition, the state lies between two major urban population centers, Philadelphia to the south and New York City to the north. Coastal New Jersey extends from the top of Sandy Hook spit to the tip of Cape May Point, a distance of 241 km. This area continually faces heavy population pressures for recreational and living space (Buckley and Buckley 1977) with the accompanying coastal development.

9. The specific study area in New Jersey was the area along the length of the New Jersey Intracoastal Waterway, 190.7 km from Manasquan Inlet to Cape May Inlet (Figure 1). This area coincides with New Jersey's barrier islands, barrier spits, coastal salt marshes (salt meadows), major back bays and lagoons, and numerous dredged material islands. It traverses Ocean, Atlantic, and Cape May counties and provides habitat for colonial nesting seabirds and wading birds.

10. While historically most of these species were dependent upon New Jersey barrier beaches for colony nest sites, most were and are still dependent upon the New Jersey salt marshes for their food. With the development of barrier beaches and attendant heavy recreational use, many formerly beach-nesting species are now also dependent upon the salt marshes and bays for nest sites as well. In 1954, New Jersey had 97,388 ha of coastal wetlands. By 1968, 10.5 percent of these had been permanently destroyed (Robichaud and Buell 1973). New Jersey has almost 10 percent of the total wetlands along the Atlantic coast and more of than half of those have been severely modified (Gusey 1976, Jacobsen 1965, Crawford 1974). Within New Jersey, salt marshes represent only 4.5 percent of the total acreage. However, they support the state's

finfish and shellfish industries and those of other east coast states as well.

11. The most serious changes in the New Jersey salt marshes have resulted from their physical alteration by human activities. Efforts to control mosquitoes in the early 1900's resulted in the draining of rich and productive shallow pools and pannes. Ditching of the salt marshes was begun in 1912 and greatly expanded in 1933 when large amounts of labor were available during the depression. Ditching is still used by mosquito control commissions in New Jersey, and their efforts have greatly modified the salt marshes since the early 1900's. During this time, heavy widespread construction on the oceanfront and increasing demand for land in this area led to filling and dredging activities in addition to those begun in 1908 for navigation channels (Nordstrom et al. 1974). These activities carried on by various Federal, State, municipal, and local bodies, as well as by individual land owners, had little or no regulation, so destruction of large areas of salt marsh occurred when high spots were created. Dredged material islands were apparently created on pre-existing salt marsh or pre-existing salt marsh islands, as well as in shallow bay waters behind the barrier beaches and in inlet areas, although little or no record of their creation exists.

12. A more detailed account of the study area and its present and past development is provided in Appendix A. Today the area is very heavily developed above the Island Beach (now a state park). Varying degrees of development are present on the barrier islands below here. Brigantine National Wildlife Refuge provides over 8173 ha of protected salt marsh area and is heavily utilized by colonial nesting species. Stone Harbor Sanctuary, a municipally owned wildlife refuge, and one of the last remaining pieces of maritime forest left on the Jersey coast, harbors the largest heronry in New Jersey. Heavy recreational use and development of New Jersey beaches have left very few undisturbed areas for nesting birds to utilize. Despite the intensive development of the barrier beaches, the marshes and bays behind them are still comparatively undisturbed though mostly ditched. Dredging operations

have produced a number of islands in these marshes and these, coupled with other high spots of undertermined, but suspected, dredged material origin throughout much of the south Jersey marshes have provided alternatives to the former nesting sites destroyed on the barrier islands. It is here that most of the species examined in this study are now found.

Dredged Material Sites

13. The specific study area contains numerous islands that are of dredged material origin. The New Jersey portion of the Intracoastal Waterway was constructed by the State from 1908-1916 and was later turned over to Federal control in 1945 (Nordstrom et al. 1974). The State maintained the channel at a depth of 1.8 m and the U. S. Army Engineer District, Philadelphia, the Federal agency that is now responsible for its maintenance and operation, has also maintained a channel depth at 1.8 m. In New Jersey, a channel depth of 3.1 to 3.7 m is maintained to provide for ferries and larger boats. The dredging operations associated with maintaining this navigation channel have been responsible for the deposition of a large part of the dredged material in the specific study area in New Jersey. Records of the precise locations where this material was deposited were not systematically kept by either the State or the U.S. Army Corps of Engineers until recently, so the exact determination of locations of islands of dredged material origin in New Jersey has been extremely difficult. Compounding the lack of State or Federal records were the dredging and filling activities of local and private interests with little or no supervision. Local mosquito control ditching activities also contributed to dredged material deposition on the salt marshes, salt marsh islands, and shallow waters of this area. State officials now consider any areas of higher elevation in the marshes to be of probable dredged material origin (personal communication, December 1976, Dr. Tom Hampton, Office of Wetlands Management, New Jersey Department of Environmental Protection, Trenton, New Jersey).

14. A study concerned with the environmental impact of maintenance

dredging of the New Jersey Intracoastal Waterway was published (Nordstrom et al. 1974) by the Marine Sciences Center of Rutgers University, New Brunswick, New Jersey. This study indicated sites along the waterway used for dredged material disposal or recommended as alternative sites in 1974 appeared upon inspection in 1977 to have been used some time in the past for disposal. Ages or dates of last deposition of these sites were not provided in Nordstrom et al. (1974). A "Final Environmental Impact Statement" issued by the Philadelphia District in 1975 is based upon the Nordstrom report.

15. The Ocean County Mosquito Control Commission, concerned with the problem of disposal locations acting as mosquito breeding grounds (Shisler 1977) and especially the diked disposal areas where improper drainage and standing water provide prime mosquito breeding habitat, instituted a study to collect and evaluate data concerning mosquito problems associated with dredged material sites in New Jersey. As part of that study, several dredged material disposal areas were located. Additional data on locations were obtained from the Ocean County Mosquito Commission but dates of deposition were not available.

16. Figure C1 of Appendix C presents the locations of dredged material study islands whose dredged material origins were recorded by either the U. S. Army Corps of Engineers or the Ocean Study Mosquito Commission. A listing of definitely known dredged material sites along the New Jersey Intracoastal Waterway, including their latitude, longitude, names (if available), and estimated (in most cases) size and age, is found in Table C1.

Study Island Selection

17. Final selection of 10 dredged material sites without and 11 dredged material sites with colonial nesting seabirds and wading birds for intensive analyses of vegetation and avifauna was made in early June 1977. Study islands tentatively selected in May for intensive study later proved to be infeasible for use as study islands. Plans by the Philadelphia District of the U.S. Army Corps of

Engineers to use several previously selected sites as dredged material disposal areas during May-August of 1977 precluded their use as study islands. A number of sites that had been selected for study in May because they supported appropriate vegetation and no colonial nesting species were found to have nesting birds in June. Conversely, several islands selected in May, because of wading birds nesting on them, were found deserted in June. Thus final selection of islands was not possible until the second survey in June.

18. Parameters used in selection of study islands with colonies were based upon the avian species composition and population of the island, as well as its location and age if known. Eleven sites supporting bird colonies were selected because one dredged material site had two distinct dredged material deposits physically separated by salt marsh and creeks, each one supporting a heronry with one also supporting a gull colony. Vegetation study islands were selected for comparison to those supporting colonies based upon a best approximation of their similarity in size, location and habitat. Age data, when available, were also an important factor. Consideration was also given to attainment of an equitable distribution of study sites along the length of the New Jersey Intracoastal Waterway in order to include the possiblilty of geographic variation in plant composition acting as a factor in colony site selection.

19. Study island locations are shown in Figure C1 and their physical and biological characteristics are discussed in detail in Appendix B, as well as in Part III of this report.

Vegetation Studies

20. In order to determine patterns of succession of vegetation on dredged material study islands, several methods of analysis of the vegetation growing on these islands were employed. Appendix B presents a detailed discussion of these methods. A summary is presented here.

Photointerpretation

21. Major plant communities were mapped using false-color infrared

Ektachrome transparencies of each study island, taken as part of the study during July-August 1977 from an altitude of 308 m. Photointerpretation was augmented by onsite ground truthing. Photointerpretation and analysis followed standard procedures (Anderson and Webber 1973, Avery 1968, Fornes and Reimold 1973). Initial analysis produced 43 tentative recognizable plant associations which were reduced to 15 plant communities. Vegetation maps were prepared from these 15 plant community designations, which were based upon dominant species composition, ground cover, and visual density. Onsite ground truthing and field transects enabled accurate determination of photographic scales and distances.

Sampling techniques

22. Ground sampling techniques included general field reconnaissance, line intercept, and quadrat sampling methods (Oosting 1958, Phillips 1959). All study islands were surveyed aerially by fixed-wing aircraft, and photographs and notes pertaining to their vegetation were taken. Ground sampling techniques and visual observation were used to determine criteria for classification of frequency, cover, and height classes for dominant or major plant species found on the 21 study islands. Table B1, Appendix B presents these classes and their equivalents. Four frequency classes were determined based upon species presence in quadrats. Cover was divided into five classes based upon the percent of ground covered in all quadrats. Height was divided into six classes ranging from 0 to 10.0 m. Dominant plant species were determined by their frequency of occurrence across all quadrats sampled on all study islands. Species exhibiting the highest percent frequency and having a cover class of at least 6 to 25 percent were determined to be dominant species. The area covered by each study island and plant community was determined by use of a dot grid.

Preservation of specimens

23. Specimens of 100 plant species were collected on the study islands. Species verification and/or identification was made by Dr. Harry E. Ahles, Herbarium Curator at the University of Massachusetts, Amherst, MA and co-author of The Manual of the Vascular Flora of the

Carolinas. Five species were not collected and are so noted in Table 3. Voucher specimens are on file at WES.

Substrates and Soils

24. Dredged material removed from the New Jersey Intracoastal Waterway consisted of sand, clay, silt, peat, pebbles, and shell and varied with location along the Waterway (Nordstrom et al. 1974). Soil samples representative of the upper 15 cm of soil were collected in the major plant communities on each study island. Samples were collected both along transect lines and within major plant communities not along transect lines. Samples were collected on all study islands and labeled as to island, location on the island, and date. Approximately 45 kg of soil samples were shipped to WES. Soil analysis was not a part of this study, though it is hoped that these samples can be analyzed chemically and physically in order to help determine factors affecting growth and succession on dredged material islands in New Jersey.

Avifaunal Studies

Survey of colony sites

25. The length of the New Jersey Intracoastal Waterway was surveyed during early May 1977 and again during the first two weeks of June 1977 to locate colonies in the specific study area. In the May survey, barrier beaches bordering the Intracoastal Waterway were surveyed as well as the salt marshes and bays surrounding the Waterway. The June survey area was confined to the length of the Waterway and to a 1.60-km-wide swath to either side of the midline of the Waterway channel. In some instances, colonies located during the May survey were surveyed again in June despite being outside of these boundaries.

26. The locations of colonies observed during these surveys were noted on hydrographic charts numbered 12,324 (Sandy Hook to Little Egg Harbor) and 12,316 (Little Egg Harbor to Cape May), published by the National Oceanic and Atmospheric Administration in January 1977. Sites

of 1976 colonies were inspected closely as were sites observed to have appropriate species flying to, from, or around them, as well as birds loafing or feeding upon them, or nearby.

27. The conveyance used for both surveys was a five-passenger (including pilot) Bell Jet Ranger 11, Model 206B helicopter. An observer was positioned on each side of the machine in the rear and a third observer was seated next to the pilot in the front. The speed flown during surveying operations was relatively slow during the actual surveying activities. Surveying altitudes varied from 15 to 60 m depending upon location and development or obstructions in the areas being flown over.

28. Island and barrier beach locations were surveyed by flying directly over them. Salt marsh areas were surveyed by flying in a looping grid pattern and in decreasing concentric circles. When birds were observed, altitude and speed were reduced, and the site was circled to determine if actual nesting was occurring. In some areas where nesting was in doubt but there were numbers of birds present, it was necessary to hover over the location (at a distance safe enough to cause no damage to the site from blowing debris or prop wash) to determine if nests were present. This was done most often in small heronries where nests were not immediately visible. Once a colony nesting site was located, counts were made.

<u>Census of colony sites</u>

29. Census techniques used in this study were concerned with the determination of the species present and the numbers of breeding adults inhabiting each colony. The term "census" is used as defined by Buckley and Buckley (1976).

30. Once a site was determined to harbor an active colony, the altitude and speed of the helicopter were reduced and the colony was circled in both a clockwise and counterclockwise direction so that observers on both sides of the aircraft could observe the colony and its inhabitants. Population determinations followed procedures already field tested during colonial waterbird censusing on Long Island, NY (Buckley et al. 1977).

31. Breeding adults in smaller colonies (under 150) were counted, either as they flew off their nests or while they sat on them. In some instances, nests were also counted when they were visible, as were clutch sizes and the number of young present in the nests. In large colonies, the site was circled several times in both clockwise and counterclockwise directions, sectional counts being taken and totalled to obtain the total population per species. Use of the helicopter's hovering abilities facilitated censusing in large colonies, especially of heronries in dense vegetation. In these situations, hovering was used at a safe distance from the colony while counts were made of breeding adults. This procedure afforded an excellent view of birds flying in and out of the colony, of nest locations, and of nest contents. It was possible to count birds nesting at the lower levels of the canopy as well as birds scurrying through vegetation beneath the canopy.

32. Census methods also included the deliberate flushing of common, least, and Forster's terns from their nests by hovering at an altitude of approximately 15 m over colony sites. The birds were then counted either singly or by extrapolating from the number of birds in a small section of the flying flock multiplied by the approximate number of similar sections. This technique caused minimal disturbance of short duration (1 to 5 minutes) and also enabled observation of the reproductive stage of the colony. Many birds seemed habituated to this form of disturbance and did not leave their nests, clinging to them despite strong downdrafts created by the aircraft's main rotor. Almost all returned to their nests within 2 to 5 minutes after being censused.

33. Colonies located on dredged material islands selected as study islands were also censused by onground methods. The helicopter was set down in an area as far from the actual colony site as possible, which allowed investigation of the entire site with only minimal disturbance to the nesting birds. The colony was first inspected from its periphery. The locations of nests and species were noted and then the colony area was entered. Species composition and population were observed as the birds left their nests. Nests that were visible were investigated as to their contents and construction materials. Their

substrate was also noted. Counts were made of the birds flying over their nesting as well as those sitting on their nests or nearby roosts. Colony sites that were densely vegetated and/or densely populated were not traversed when disturbance factors outweighed the necessity for data gathering from the ground. In colonies where disturbance would be minimal, nests were counted in addition to the adult population.

Recording of data

34. Data gathered during aerial surveying, ground truthing, and censusing of the study area and of dredged material islands were recorded on field data sheets designed especially for this project (Figure 2). Data gathered included: colony name, site latitude and longitude, date, time, dredged material island number, the colony areal extent, county, if the island was diked or undiked, colony number, general colony habitat, colony history (if known), with any other pertinent data under a remarks category, species present, total population in pairs, nesting stage, and the nest site substrate. The categories of general colony habitat, colony areal extent, nesting state, and nest site substrate were given numerical codes (Table 1) corresponding to the various habitats, position on the colony site, stage of the reproductive cycle, vegetation, and soil substrates found within the study area. The colony number and location were recorded on hydrographic charts for later reference. Figure C2 in Appendix C shows the colony sites recorded in 1977 along the New Jersey Intracoastal Waterway. In some instances colony sites are shown despite their location outside the boundaries of the specific study area.

35. Aerial color photographs (35-mm transparencies) were taken of each colony site at the time of the census and survey. Sketches of the colony sites and vegetation on the study sites were also made and photographs (color, 35-mm transparencies) were also taken of the colony sites from the ground.

Data disposition

36. Field data sheets, hydrographic charts showing colony site locations in 1977, 35-mm color transparencies of colonies of colonial

COLONIAL WADING BIRD AND SEABIRD AERIAL SURVEY - N.J. INTRACOASTAL WATERWAY - 1977

COLONY NAME ______

LATITUDE ______ LONGITUDE ______ DATE ______ TIME ______

DREDGED MATERIAL IS. # ______

DIKED ______ UNDIKED ______

COLONY AREAL EXTENT ______

COUNTY ______

COLONY # ______

GENERAL COLONY HABITAT ______

COLONY HISTORY ______

REMARKS ______

SPECIES PRESENT	TOTAL POPULATION	NESTING STAGE	NEST SITE SUBSTRATE

Figure 2. Field Data Sheet

Table 1

Key to Field Data Codes

COLONIAL WADING BIRD AND SEABIRD AERIAL SURVEY - N.J. INTRACOASTAL WATERWAY - 1977

KEY TO DATA SHEET CODING

I. GENERAL COLONY HABITAT

1. salt marsh 2. salt marsh island 3. dredged material island 4. island of unknown origin 5. barrier island 6. marsh island with dredged material deposition 7. salt marsh w/ dredged material deposition 8. construction fill 9. barrier island spit 10. natural sand shoal

II. COLONY AREAL EXTENT

1. scattered throughout island 2. scattered around island edge 3. scattered over island center 4. scattered over one end of island 5. clustered at island center 6. clustered at one end of island 7. scattered over salt marsh 8. clustered in salt marsh 9. other

III. NESTING STAGE

1. pairing/courtship 2. territory establishment 3. nest building 4. egg-laying 5. incubation 6. hatching 7. young in nest 8. young out of nest 9. young ready for flight/flying 10. loafing at site

IV. NEST SITE SUBSTRATE

1. trees-coniferous 2. trees-deciduous 3. trees-mixed 4. tall shrubs [above 3M.] 5. medium shrubs [1-3M.] 6. low shrubs [less than 1M.] 7. mixed shrub-*Phragmites* 8. *Phragmites* 9. herbaceous [non-grass] 10. grasses 11. salt marsh wrack 12. salt marsh 13. sand 14. sand-shell 15. sand-shell-gravel 16. other

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seabirds and wading birds nesting in the specific study area, 35-mm transparencies of dredged material islands along the New Jersey Intracoastal Waterway, and false-color, infrared aerial imagery of the 21 dredged material study islands in New Jersey, were sent to WES.

Analysis

37. Analysis of the data was confined to examination of the general habitat of all colonies located on these surveys. The population numbers of the species censused, as well as the number of colony sites found in each of the ten habitat types, were compared. Data gathered on the 11 dredged material bird study sites were analyzed in more detail. The environmental setting of each colony was examined in detail. Bird colony maps for each study island were prepared as overlay maps to be fitted over the vegetation maps of the study islands. The colony area and each part of the colony within differing plant communities were determined from these maps by use of a dot grid.

38. Plant communities on study islands without bird colonies were compared to plant communities on study islands with bird colonies, with emphasis being placed upon those plant communities present within colonies. It was necessary to analyze plant communities in detail to determine similarities and differences between the 21 study islands. Statistical tests were used to determine the significance of relationships and differences and to look for relationships among islands, plant communities, and bird colonies.

39. Statistical methods. All statistical testing and mathematical computations were done on a programmable pocket computer using preprogrammed statistical tests, or by writing programs for short, repetitive tests when those were not already avilable. General statistical references used were Sokal and Rohlf (1969) for parametric tests and Siegel (1956) and Conover (1971) for nonparametric tests. The level for all tests was $P \leq 0.05$.

40. Frequency, cover, and height vegetation data. Frequency, cover, and height classes for each dominant species in each plant community sampled were averaged to obtain one set of frequency, cover, and height scores for each community on a dredged material study island.

Vegetation on islands with birds was statistically compared to islands without birds through T-tests.

41. Importance values were not calculated. Cover and height scores were added whenever available for plant communities on each study island.

42. Plant community distribution. To compare plant species occurrence and associations, the homogeneity of distribution was tested with the Cochran Q-test. Plant communities on all study islands were scored as present (+) or absent (-) on both vegetation and bird study islands in two row-by-column formats. They were analyzed on a bird islands vs. vegetation islands and herons islands vs. all other islands basis comparison using T-tests.

43. Avian and vegetation diversity indices. In an attempt to quantify both vegetation and bird diversity by use of a single measure, Shannon-Weiner (Wilson and Bossert 1971, Pielou 1977) Indices of Diversity $\{H' = -\Sigma P_i \ln P_i\}$ were calculated for each study island. Raw data were percentages of hectares occupied by each plant community on each island and the percent occurrences of each wading bird species on each bird study island (Pielou 1977). Plant diversity indices for all vegetation study islands and bird islands were pooled separately and compared by use of t-tests. Possible relationships between plant diversity indices and the age (based upon the last known date of dredged material deposition) of each deposit were investigated by the use of regression analysis, using plant diversity indices as the dependent variable and age as the independent variable. Plant diversity was regressed on deposit size. Bird groups other than herons were not studied in this manner because they were not sufficiently diverse in colony species composition to warrant this analysis.

44. Avian and vegetation association data. Detailed analyses of the interactions between birds and vegetation were generally pursued for only the wading birds, as they were the only group found on enough study islands with large, mixed-species colonies of sufficient size and dimensions to allow this. Herring gulls, though occasionally containing a few great black-backed gulls in their colonies, were the only other

birds occurring in large enough numbers and at enough study sites to warrant analyses. Cochran Q-tests were used for analysis.

45. An association matrix of possible combinations of eight major variables for possible investigation was devised. Included were: island size, deposit size, colony extent, bird density, bird species diversity, planting community diversity, the combined percentages of common reed (*Phragmites communis*), common reed-shrub, shrub, and shrub-forest communities occupied by the colony on each heron island, and colony size. Regression analyses were done between certain variables and certain data distributions and/or variable interrelationships necessitated data transformations before the assumptions of linear regression analysis could be met.

46. Regression analysis was used to investigate the relationship between plant diversity indices on study islands supporting heronies and (a) plant diversity indices for vegetation study islands only, and (b) for all study islands excluding those with heronries. It was also used to examine relationships between plant diversity indices of study islands and between plant diversity indices for all bird and vegetation study islands. All regression slope coefficients were tested for significant deviations from a slope of zero by the use of t-tests.

PART III: RESULTS

Dredged Material Study Islands

47. Twenty-one dredged material islands were chosen for detailed study of vegetative and physical characteristics that could possibly affect the selection or rejection of dredged material islands as breeding colony sites by seabirds and wading birds. Eleven of these sites supported active bird colonies during June 1977 when field studies were undertaken. These colonies were examined to elucidate factors used in colony site selection by the birds. One dredged material site, 98B, had two distinct dredged material deposits upon it and each supported an active heronry. (The terms "heronry" and "herons" are used collectively in this report to include egrets, ibises, and herons.) Thus, this site consisted of two separate study islands, 98B North and 98B South, separated by creeks and salt marsh, increasing the number of study sites actually supporting bird colonies to 11 sites. Ten sites did not support active bird colonies during June 1977 when surveyed and these were considered vegetation study islands, or "control sites." Overlay maps of the bird colonies were prepared for each bird study island, and vegetation maps were prepared for all study islands. Physical characteristics determined for each study island included: (a) island and/or dredged material deposit size; (b) latitude and longitude; (c) date of last known dredged material deposition; (d) elevation; (e) distance from the New Jersey Intracoastal Waterway; (f) presence and estimated extent of adjacent tidal flats; and (g) presence or absence of diking. Table 2 gives these characteristics for each study island. Bird colony data for each bird study island are listed in Appendix C. A detailed analysis of vegetation on each study island is presented in Appendix B.

Table 2

Physical Characteristics of Study Islands

Island #	Island Size (ha)	Deposit Size (ha)	Diked (D)/ Undiked (U)	Date of Last Deposit	Elevation (m)	Tidal Flat Extent (ha)	Distance to NJICW (km)	Tidal Range (m)
A12	2.61	2.30	U	pre 1969	2.4-3.6	1.26	1.20	0.15
A12 North	6.38	0.61	U	pre 1969	1.5-2.4	---	1.33	0.15
A35	2.49	1.20	U	pre 1969	1.0-1.5	---	0.16	0.3
A43a	8.08	1.13	U	?	<1.0	---	0.28	0.67
45A	5.58	2.55	D	1976	1.5	---	0.08	0.67
45B	1.62	1.05	U	1963	<1.0	---	0.12	0.67
X27	13.17	0.69	U	pre 1969	1.0-1.5	1.75	0.40	0.79
51B	16.97	1.78	U	1965	1.0	---	0.32	0.79
A61c	5.49	3.47	U	pre 1969	1.0-1.5	---	0.12	1.03
A59a	2.42	2.42	U	1968	1.0	1.21	adj.	1.03
85dmi	3.07	2.38	U	1966	<1.0	---	adj.	1.1
85 South	13.63	0.70	U	1966	0.5	---	adj.	1.1
98A	5.94	0.76	U	1968	<1.0	5.05	0.20	1.3
108B	2.83	0.20	U	1965	<1.0	0.17	adj.	1.3
98B North	14.54	0.47	U	1968	<0.5	1.33	adj.	1.3
98B South	14.54	0.89	U	1968	<0.5	1.33	adj.	1.3
78B South	50.90	3.43	U	1969	1.0-2.0	---	0.40	1.2
103	129.28	1.18	D	1975	0.31	0.31	adj.	1.2

(Continued)

Table 2 (Concluded)

Island #	Island Size (ha)	Deposit Size (ha)	Diked (D)/ Undiked (U)	Date of Last Deposit	Elevation (m)	Tidal Flat Extent (ha)	Distance to NJICW (km)	Tidal Range (m)
85C	13.63	3.96	D	1976	1.5	0.14	adj.	1.1
109	81.0	5.28	U	1965	1.5	5.30	adj.	1.3
109 South	5.00	5.00	U	1965?	1.0	0.3	adj.	1.3

Description of Islands

Study Island A12, Pelican Island

48. Study Island A12 (Pelican Island) is a circularly shaped, high-domed island partially covered with undiked dredged material. Located in Ocean County at 39^{o} 57' N and 74^{o} W, it is approximately 2.6 ha in size with a dredged material deposit approximately 2.3 ha in size. The deposit area comprises all but a thin marsh and sand fringe of the island. An elongate salt marsh island lies between A12 and cottages on the barrier beach at Ortley Beach, only 1.8 km away. The study island is close to three marinas and receives frequent human visitation. A sandy spit on the southwestern side and the entire western face are sites of heavy recreational use (picnicking, sun bathing, boating rest stops) from the nearby barrier beach communities.

49. Estimated elevation (2.4 to 3.6 m) of the island is the highest of those studied. The dredged material deposit predates 1969 (personal communication, June 1977, Fred Lesser, Ocean County Mosquito Control Commission, Barnegat, NJ). The tidal range on this island is 0.15 m, and 1.26 ha of tidal flats are adjacent to the island. The New Jersey Intracoastal Waterway is 1.20 km from the study island.

50. Pebbles (8 to 20 mm in size) mixed with sand and quahog shell fragments are found at the summit of the sparsely vegetated dome. The lower areas are composed mostly of sand, but also contain pebble and shell. A small amount of debris is scattered over the dome. The western or high energy side of the island is eroding to some degree. The usual circular dredged material deposit shape is flattened on the west side, and the sandy dome sloped down to the water's edge without the bands of marsh and upland vegetation found on the other sides.

51. Pelican Island has both early seral stage and mid seral stage vegetation. However, the island is characterized (Appendix B) as being an early seral stage island. The sparsely vegetated dome covers most of the island and its vegetation of low grasses consists mostly of: brome grass (*Bromus tectorum*), sand-grape (*Triplasis*

purpurea), vulpia (*Vulpia octoflora*), and tumble grass (*Eragrostis spectabilis*), and the herbs, small fleabane (*Erigeron pusillus*) and evening primrose (*Oenothera parviflora*). Taller herbs and grasses, seaside goldenrod (*Solidago sempervirens*), American beachgrass (*Ammophila breviligulata*) and common reed (*Phragmites communis*), occur around the lower half of the dome and are most frequent on the eastern side. Surrounding the sparse grassland is a band of common reed. Scattered bayberry (*Myrica pensylvanica*) and groundsel (*Baccharis halimifolia*) are occasionally found with the common reed, either singly or in small thickets. A thin band of salt marsh surrounds all but the western face (Figure 3).

52. The sparsely vegetated sand and pebble substrate of the study island is probably a major factor in its selection by a number of least terns (*Sterna albifrons*) as a colony nest site. Least terns nested on the island in 1976 (Kane and Farrar 1976), and during the 1977 survey and census, 76 least terns were observed loafing on the site. By 7 June 1977, 240 pairs of least terns had nests and eggs scattered over most of the dome (Figure 4). This colony is the largest least tern colony in New Jersey in 1977. The nearest least tern colony site is at Barnegat Inlet, a distance of 20.11 km.

Study Island A12 North, Pelican Island North

53. Island A12 North (Pelican Island North) is an irregularly shaped, undiked dredged material island. Located in Ocean County at 39° 57' N and 74° 05' W, it is west of Ortley Beach, New Jersey, and directly north of study island A12. The dredged material deposit is about 1.6 ha in size and the entire island is approximately 6.4 ha in size. The dredged material deposit was built before 1969 (F. Lesser, 1977, personal communication). The island is located within 1.8 km of marinas and cottages on the barrier beach and receives frequent human recreational use on its sandy beach from boaters and local residents. The island's elevation was estimated to be 1.5 to 2.4 m, and its tidal range was 0.15 m. Its distance from the New Jersey Intracoastal Waterway

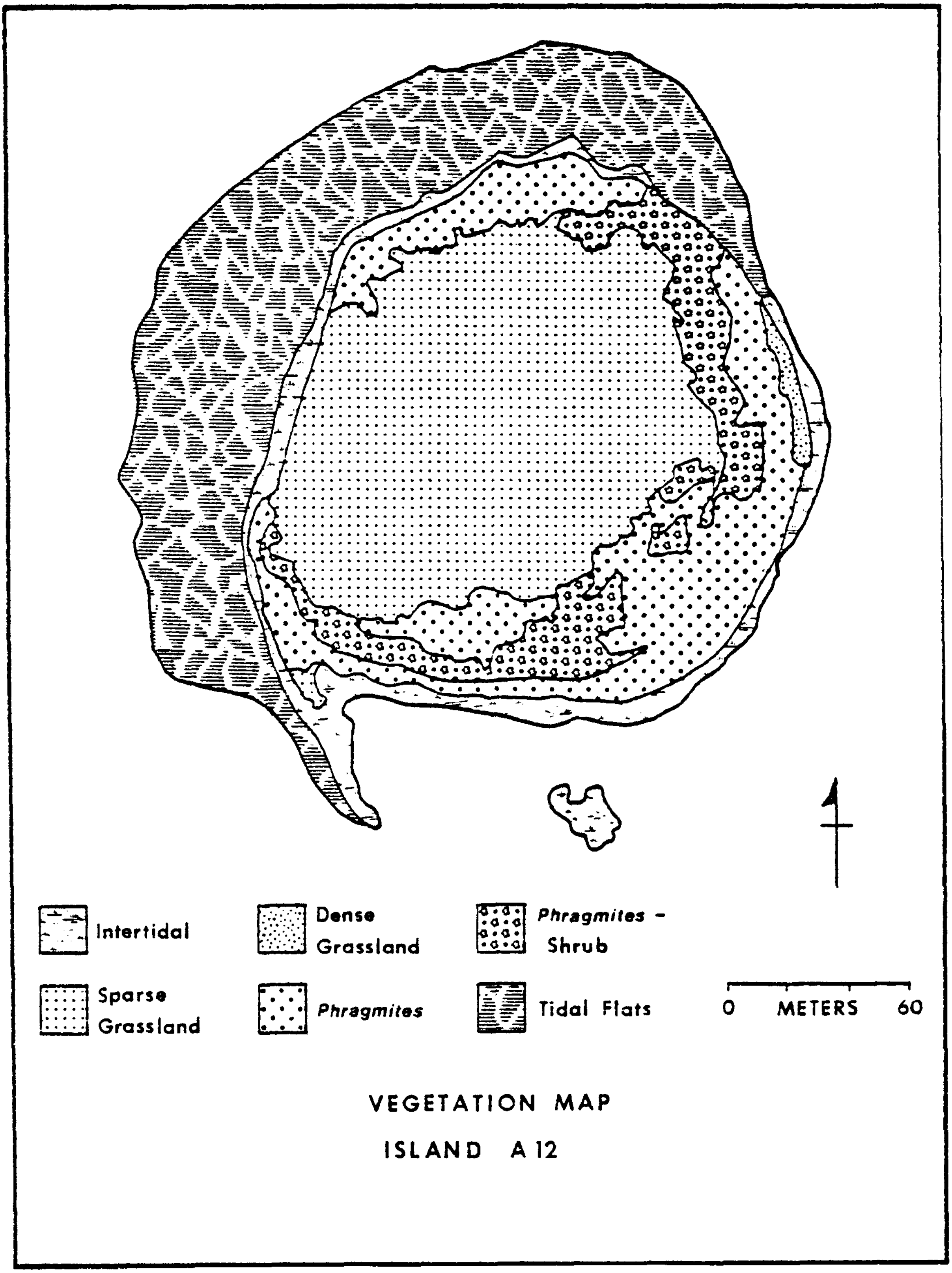

Figure 3. Vegetation map of Study Island A12

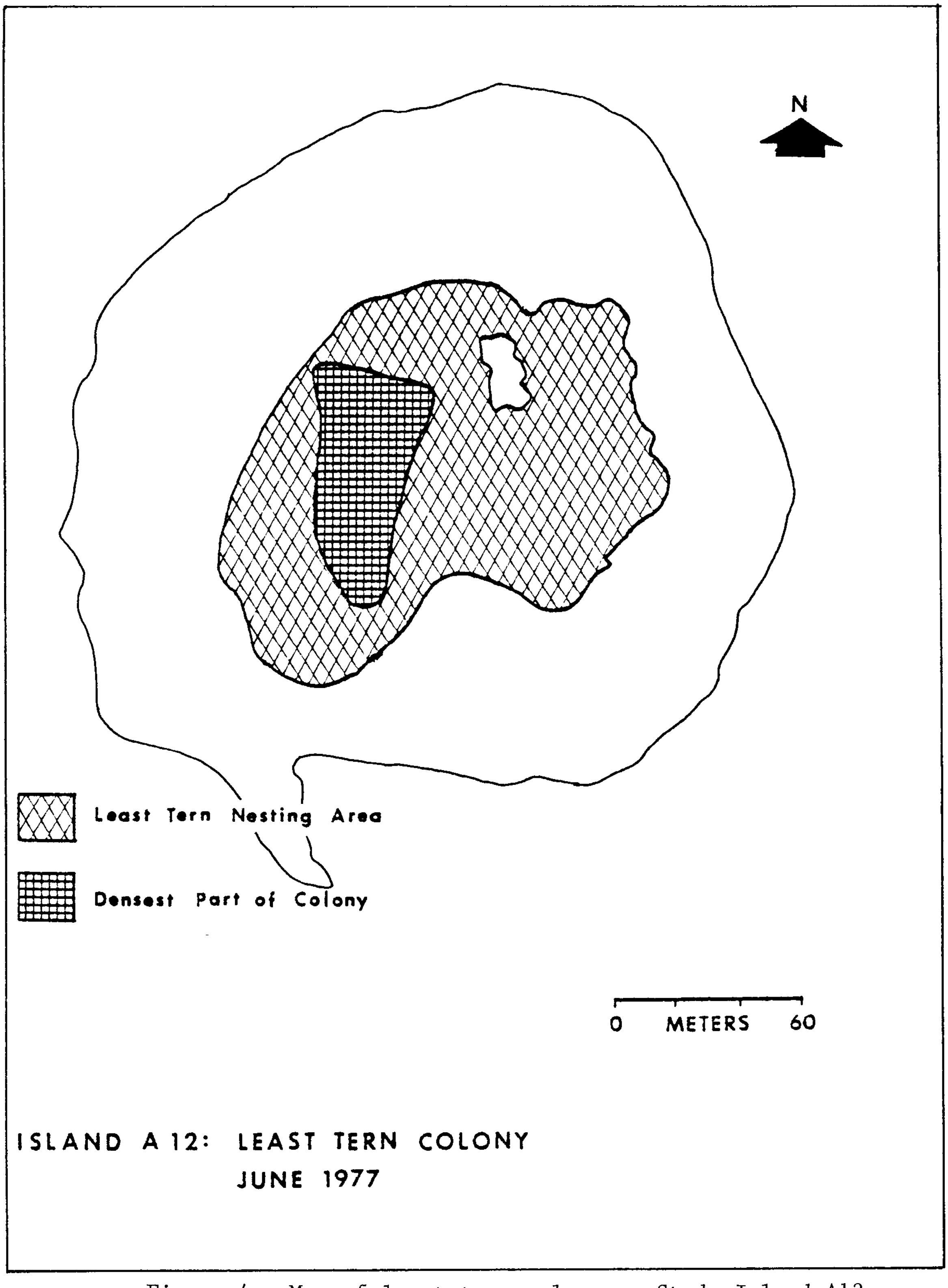

Figure 4. Map of least tern colony on Study Island A12

is 1.33 km. No extensive tidal flats were observed.

54. The study area on this island exhibited the earliest seral stage vegetation of any undiked dredged material study island without a bird colony. Mid and late seral stage vegetation was, however, present on the island, although the area studied was characterized by early seral stage vegetation (Appendix B). A band of salt marsh separated the dredged material deposit studied from an older double-domed deposit on the west side of the island that had sparse to dense grassland surrounded by shrub thickets that contained scattered trees and extensive stands of common reed.

55. The island had a domed center of bare sand with some pebble and shell. The base of the dome was encircled by a sparse grassland of low common reed which graded into taller reed approximately 1.5 m high. Portions of the common reed covered area were mixed with individuals or thickets of 1-to 1.5-m-high bayberry and groundsel shrubs. At the upper border of the salt marsh, the common reed mingled with saltmeadow cordgrass (*Spartina patens*) (Figure 5). While A12 North did not support any seabird or wading bird colonies, least terns from the nearby colony on Pelican Island did utilize its sandy areas for loafing during the 1977 nesting season.

Study Island A35, East Carvel Island

56. Island A35 (East Carvel Island) is an irregularly shaped, undiked dredged material island that was probably originally a salt marsh island which had dredged material deposited upon it. Located in Ocean County at 39° 41' N and 74° 10' W, it has not received any dredged material deposition since at least 1969 (F. Lesser, 1977, personal communication). The study island is northwest of Surf City, about 24.1 km north of Beach Haven Inlet, and 0.16 km from the New Jersey Intracoastal Waterway. The upland portion of A35 is about 1.2 ha in size and the entire island is approximately 2.5 ha.

57. East Carvel Island is a low, fairly flat island, mostly at or near sea level, with its highest portions probably only 1.0 to 1.5 m

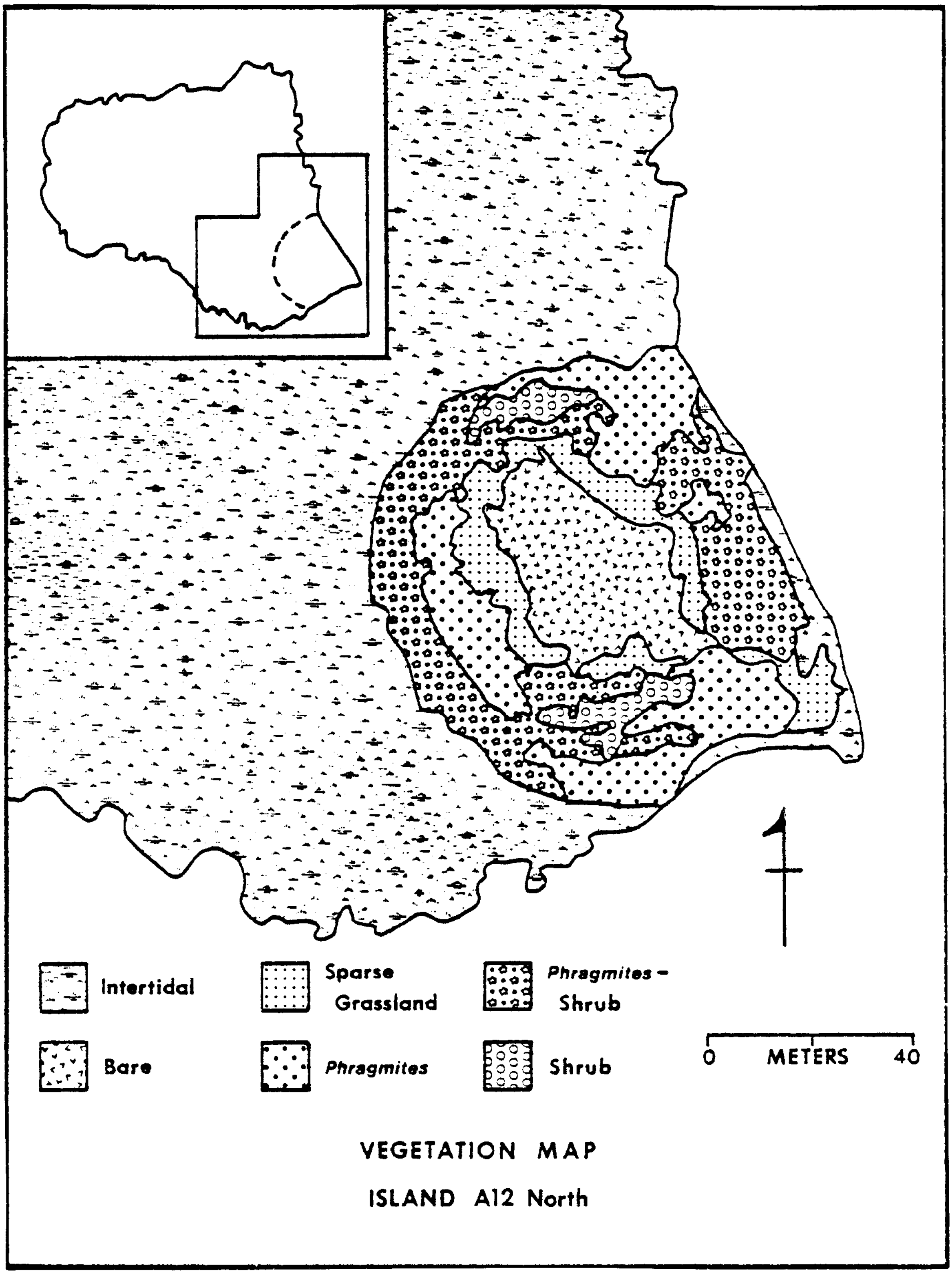

Figure 5. Vegetation map of Study Island A12 North

high. Its tidal range is 0.3 m, and the island is regularly inundated during storm high tides as evidenced by the deep drift mats and flotsam covering its interior (Figure 6). This island was unique among those studied in New Jersey because of the distribution and abundance of the cordgrass and reed stem drift, not only at the interface of salt marsh and upland, but also in vast mats in varied stages of plant succession throughout the interior of the island. High marsh vegetation chiefly reached into some interior portions of the island and is shown as dense grassland on the vegetation map for this island.

58. Vegetation on A35 was characterized by an early successional stage, but portions of the island also exhibited vegetation indicative of mid and late successional stages. The interior of the island was dominated by common reed which grew densely in some places. Frequently live and dead bayberry and groundsel were found among the reed, with a mixture of live and dead marsh elder (*Iva frutescens*), also mixed with common reed, wild morning glory (*Convolvulus sepium*), and orach (*Atriplex patula*).

59. Large areas of the island had exposed drift material. It ranged from scattered bare stems and debris to about 50 percent of low herbs and grasses. The earliest invaders of the drift were common reed and sea rocket (*Cakile edentula*). The later stages were vegetated by goldenrod (*Solidago tenuifolia*), seaside goldenrod, wild morning glory, poor-man's pepper (*Lepidium virginicum*), and wild bean (*Strophostyles helvola*) as well as sea rocket and common reed. Poison ivy (*Rhus radicans*) and bayberry were also present and represented transition into the mid seral stage. These successional drift areas were mapped as dense grassland on the vegetation map (Figure 7) unless characterized by a good growth of reed in which case they were included with adjacent reed or reed-shrub communities. The extent of the drift can be seen on a drift overlay of the island (Figure 6).

60. East Carvel Island supported a colony of common terns (*Sterna hirundo*) (160 pairs), black skimmers (*Rynchops niger*) (7 pairs), and one pair of herring gulls (*Larus argentatus*) in June 1977. The birds were distributed over most of the exterior portions of the island.

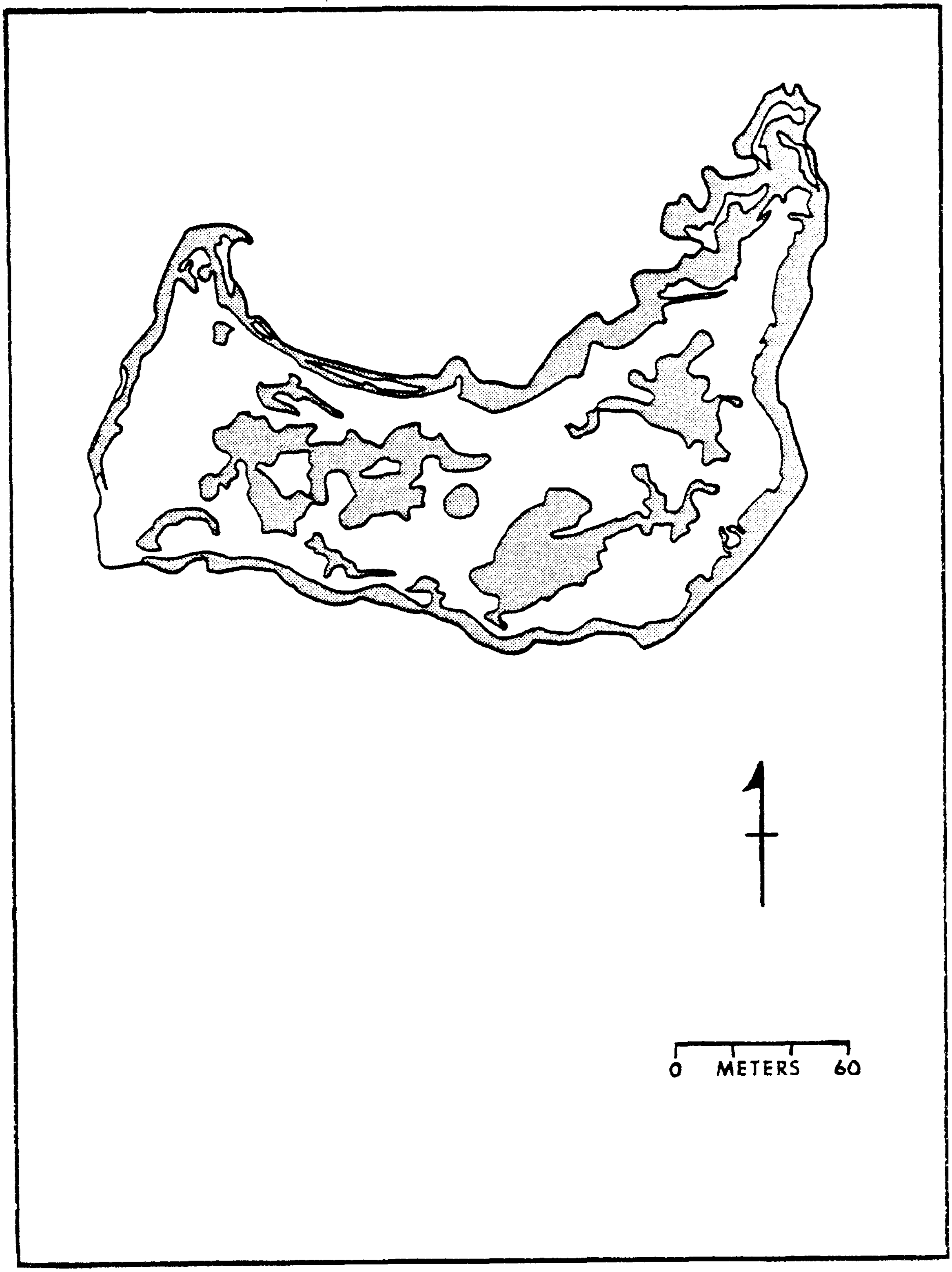

Figure 6. Drift map of Study Island A35

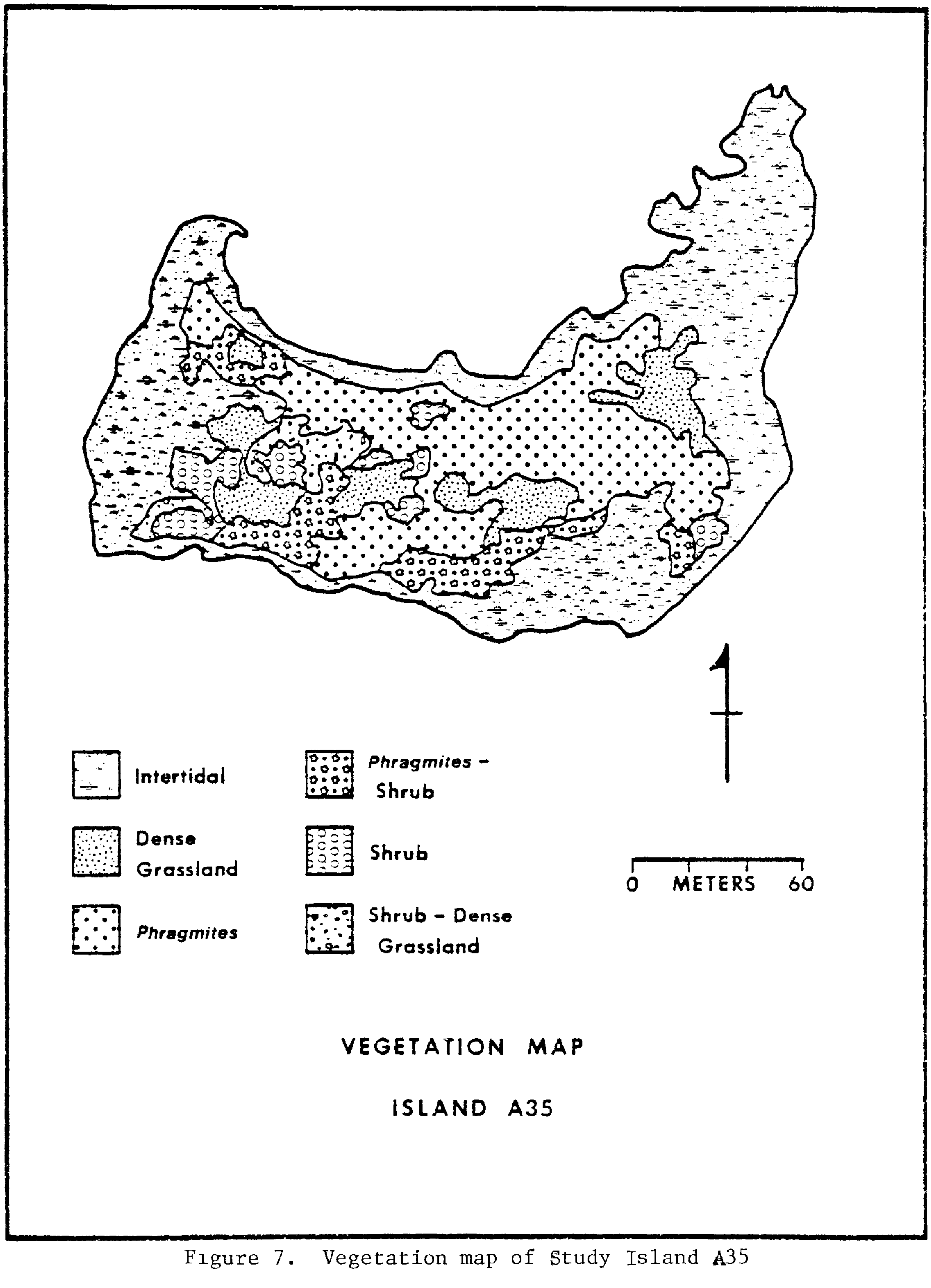

Figure 7. Vegetation map of Study Island A35

(Figure 8). The nearest colony with the same species present was only 0.24 km away on West Carvel Island. In 1976, A35 had only a small common tern colony (45 pairs) nesting on it (Burger and Lesser 1976).

Study Island A43a, Ham Island

61. Island A43a (Ham Island) is an irregularly shaped, undiked dredged material island that probably was a natural island originally, but later had dredged material deposited upon it. Located in Ocean County at 39° 36' N and 74°13' W, it is 11.3 km north of Beach Haven Inlet and 0.28 km from the New Jersey Intracoastal Waterway. The southeastern tip of the island had a dredged material deposit of 1.13 ha. The entire island is almost 8.1 ha. The tidal range at Ham Island is 0.67 m. It is a low, fairly flat island with elevation under 1.0 m. Most of the island is salt marsh with drift mats concentrated near the daily high tide mark. The dredged material area has only a slight elevation and is covered with tall vegetation.

62. The vegetation is considered to be of an early seral stage (Appendix B), though mid seral stage vegetation is also present. A dense growth of common reed dominates the dredged material area. Portions of it are mixed with abundant 1.0 to 1.5-m high bayberry and groundsel. High marsh vegetation extended into the interior of the common reed associations as indicated in Figure 9.

63. Ham Island has supported nesting common terns in the past (Appendix A), but more recently a common tern colony was located only 0.16 km away on a small salt marsh island lying between Ham Island and the barrier beach island east of it, indicated in Figure C2 as colony A43a, Little Ham Island. Common terns nested on Little Ham Island in 1976 (Burger and Lesser 1976, Kane and Farrar 1976), and in 1977 its numbers had increased to 60 pairs. Eight pairs of black skimmers were also found nesting. This small salt marsh island has been referred to as Ham Island by past workers (Burger and Lesser 1976, Kane and Farrar 1976), so earlier references to Ham Island as a nesting site (Frohling 1965) might refer to this site rather than to Island A43a. Common terns utilized the island edges for loafing in 1977.

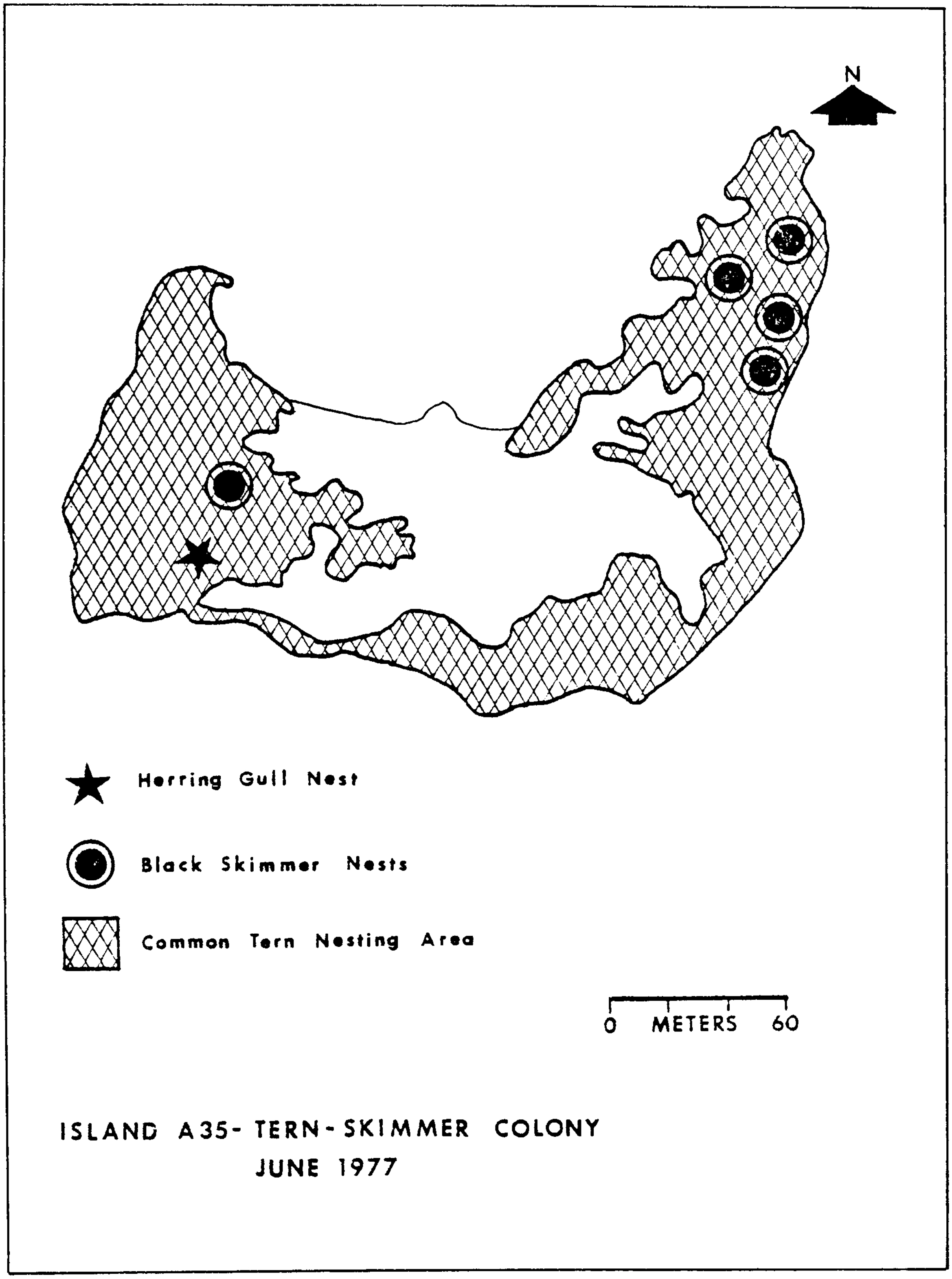

Figure 8. Map of common tern-black skimmer colony on Study Island A35

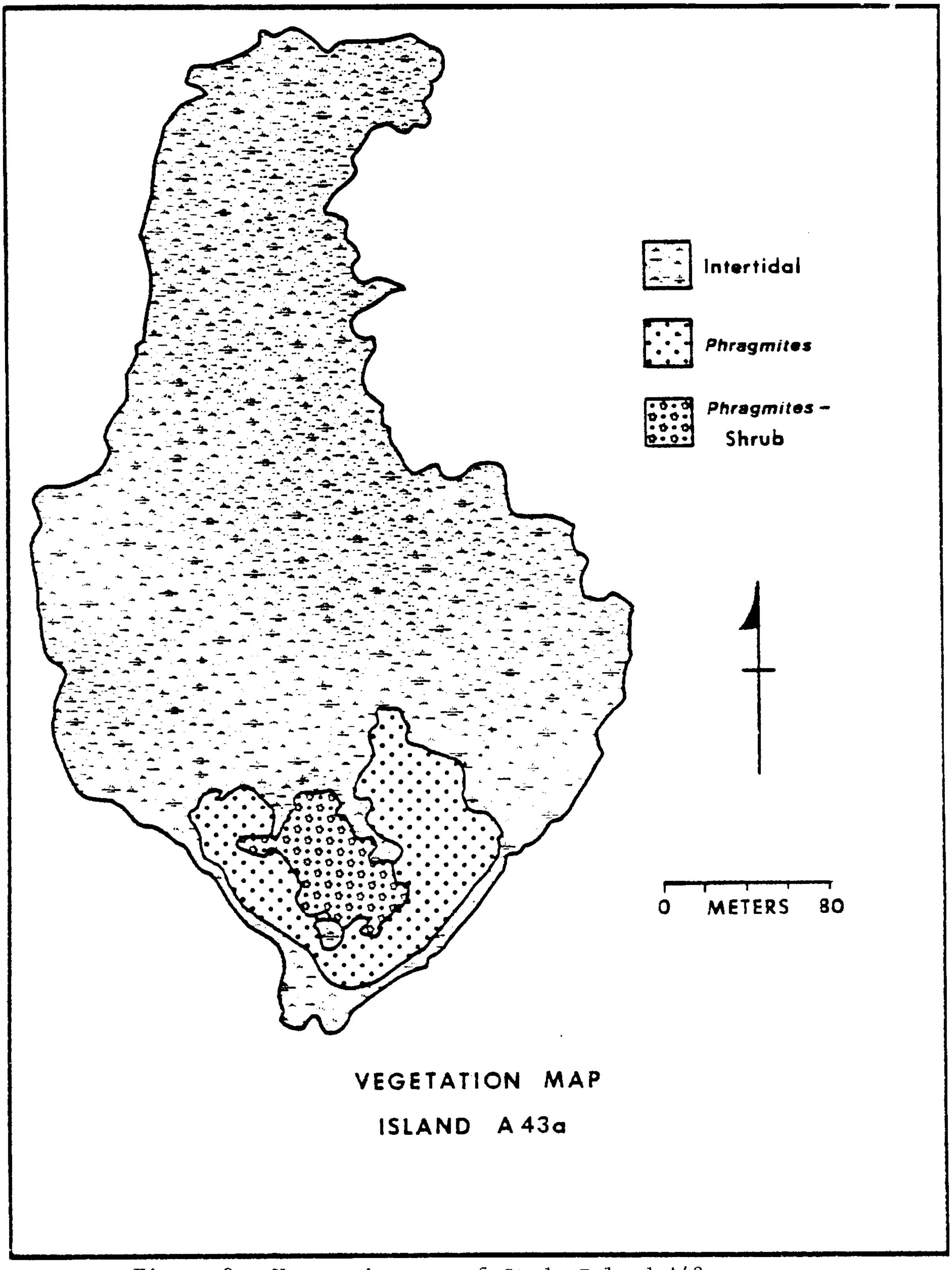

Figure 9. Vegetation map of Study Island A43a

Study Island 45A. Parker Island

64. Island 45A (Parker Island) is an irregularly shaped, diked dredged material island 5.5 ha in size. Located in Ocean County at 39° 34' N and 74° 15' W, it is situated about 8 km north of Beach Haven Inlet and is within 1.8 km of cottages and marinas on the developed oceanfront barrier beach. The island is 0.1 km from the New Jersey Intracoastal Waterway. Approximately half of the island (2.55 ha) is dredged material, with the remainder salt marsh. The last dredged material deposition on the island was in 1976. The actual extent of the most recent deposition is uncertain, but it did not include the center of the island. This island also received dredged material deposition in 1963, 1966, and 1967. Although the Philadelphia District planned to utilize it as a deposition site again in 1977, when least terns were found nesting upon it, they did not (personal communication, May 1977, M. Bartlett, U.S. Fish and Wildlife Service, Absecon, NJ).

65. The tidal range at Parker Island was 0.67 m. The island varied in elevation from sea level at the northern end to 1.5 m high on the dike at the southern end. The deposition inside the dike was gradually sloped to a slight summit approximately 1.0 m high.

66. Parker Island vegetation was indicative of an early seral stage. However, there was a short row of Austrian pine (*Pinus nigra*) seedlings present within the diked portion of the island. The 1.0-m wide dike had a varied flora dominated by common reed and included red fescue grass (*Festuca rubra*), saltmeadow cordgrass, seaside goldenrod, orach, and wild morning glory. Inside the dike was a band of bare sand and shell (whole and fragmented). Common reed culms and an occasional dead shrub protruded from the sand. The southern end of this bare area had slightly more common reed than the northern end. It also had more lumber debris, and the surface had several areas with smooth contours at the northern end. Cracked clay was evident near the outfall pipe.

67. At the center of the island (Figure 10) was a dense grassland dominated by saltmeadow cordgrass. Seaside goldenrod, Canada

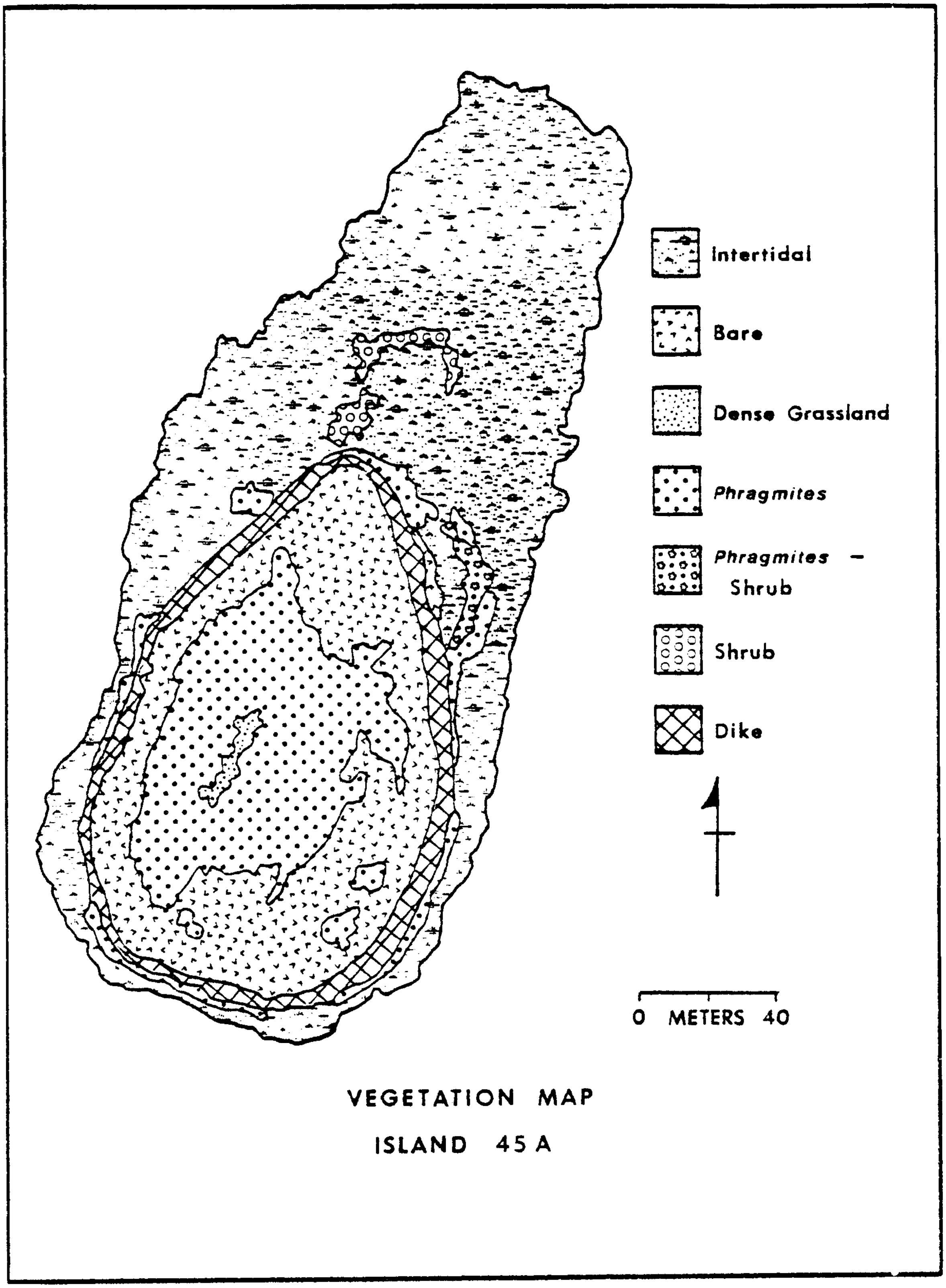

Figure 10. Vegetation map of Study Island 45A

thistle (*Cirsium arvense*), and Indian hemp (*Apocynum cannabinum*) were abundant with scattered bayberry, groundsel, and common reed. Sand, clay, and whole shell substrate supported the grasses. Between the grassy center and the bare area was a solid stand of common reed about 1.5 m high.

68. Parker Island supported a small least tern colony in 1977. On 13 May 1977, 6 to 7 pairs were observed on the island. By 7 June 1977 there were 20 pairs with nests and eggs present within the diked area (Figure 11). The dredged material of bare sand mixed with shell and gravel was probably the major factor in their selection of this island as a nest site. The nearest least tern colony was located at Holgate (colony 28, Figure C2), a distance of 6.8 km.

Study Island 45B

69. Island 45B is an irregularly shaped, undiked dredged material island. Located in Ocean County at 39° 34' N and 74° 15' W, it is directly west of Study Island 45A, 8 km north of Beach Haven Inlet, and 0.12 km from the New Jersey Intracoastal Waterway. A house is situated on the middle of the island. The island was last used for dredged material deposition in 1963 and is 1.6 ha in size, with about 1 ha of it covered by dredged material. Tidal range at 45B is 0.67 m. It is a low, fairly flat island with an elevation probably less than 1.0 m.

70. The island vegetation was characteristic of an early seral stage, but mid and late seral stage vegetation was also present. A small salt marsh bordered the dredged material deposition, its upper edge bordered by marsh elder. The marsh elder met a dense stand of common reed, and was more open at the center of the island than near the marsh. Bayberry and groundsel were occasionally scattered through the common reed. A lawn surrounded the house (Figure 12). Because the island is privatly owned, and is similar to other islands studied, minimal field work was done on this island.

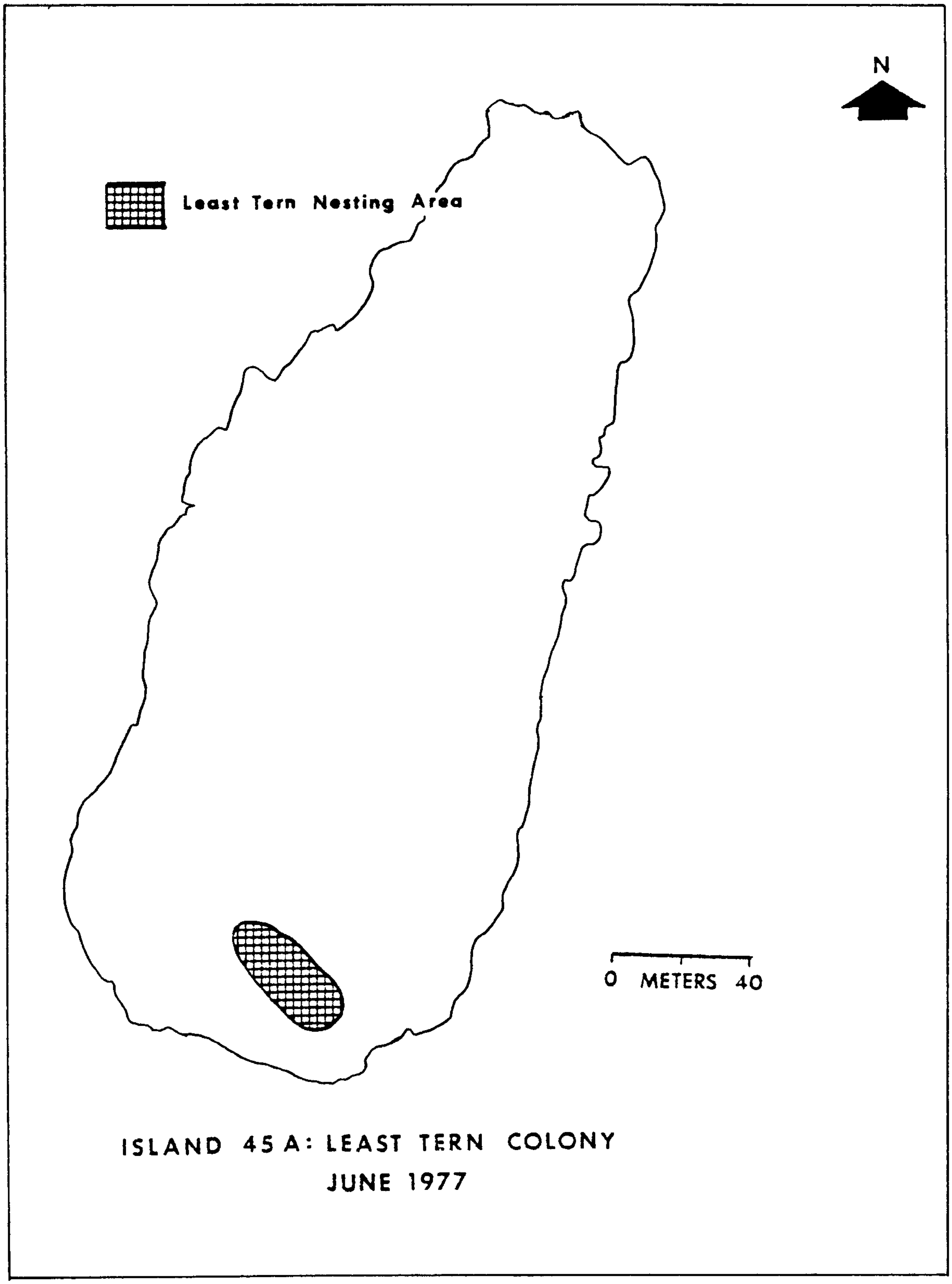

Figure 11. Map of least tern colony on Study Island 45A

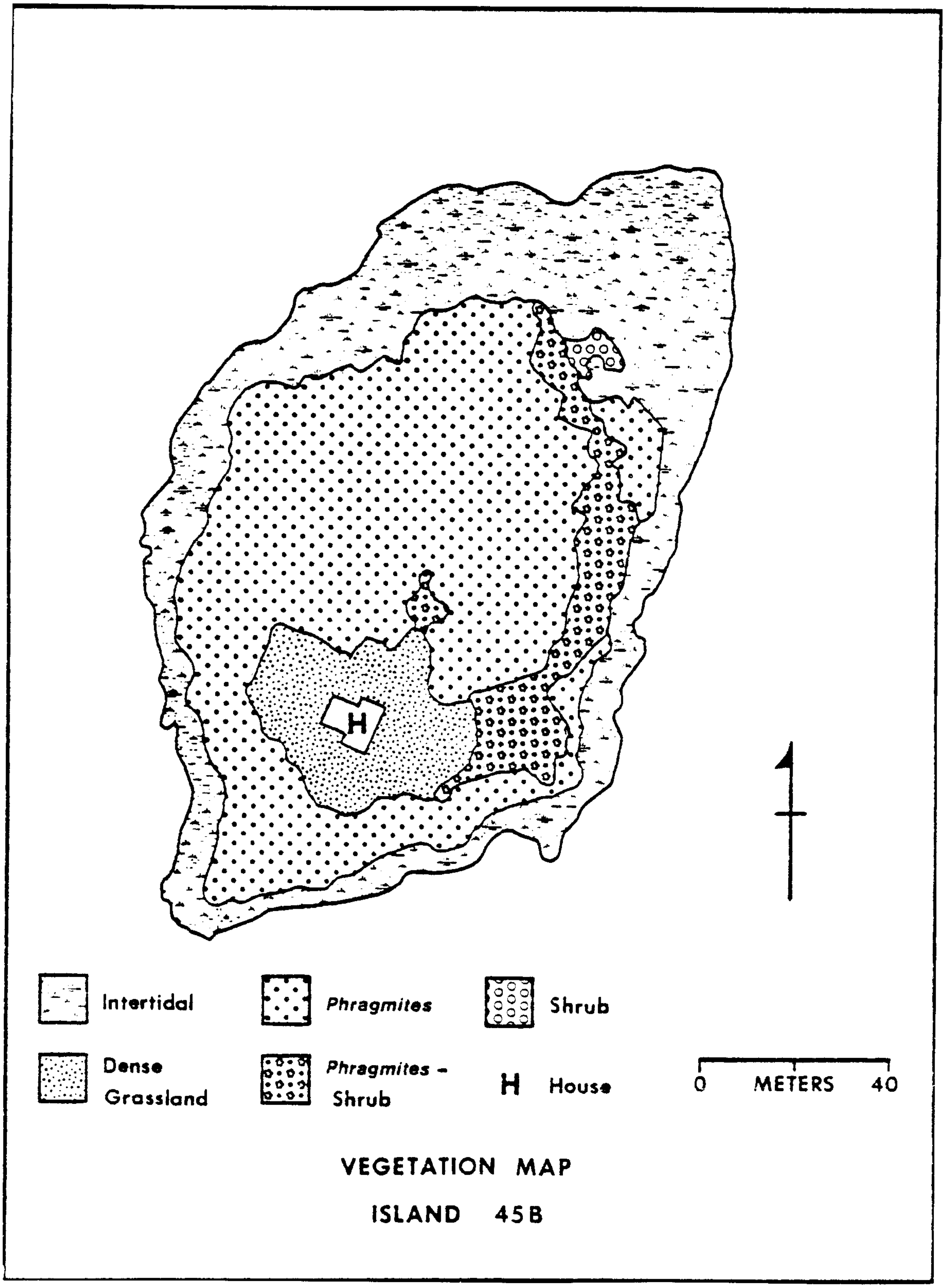

Figure 12. Vegetation map of Study Island 45B

Study Island X27, Goosebar Sedge

71. Island X27 (Goosebar Sedge) is a low, irregularly shaped, undiked dredged material island. Located in Ocean County at 39^{o} 32' N and 74^{o} 17' W, it is 0.40 km from the New Jersey Intracoastal Waterway and 3.2 km northwest of Beach Haven Inlet. The island is 13.2 ha in size and is mostly salt marsh. At low tide, extensive tidal flats surround the island. The dredged material deposition measures only 0.7 ha and is irregularly elongate on the northeastern side of the island.

72. Stone (1937) refers to the establishment of a black skimmer colony in 1930 on a "sand island created by dredging in the bay west of Beach Haven" that he calls "Goosebar Island," and that is probably Goosebar Sedge. In 1931, the black skimmers were again nesting on the island (Appendix A). This dredged material island has probably not been deposited upon recently, at least since 1969 (F. Lesser, 1977, personal communication). It is not known if there was any dredged material deposition upon the island between 1931 and 1969.

73. Elevation of the island was low, with a central ridge rising to about 1.0 to 1.5 m. The tidal range on the island was 0.79 m, and the presence of drift on the ridge indicated some storm tide inundation. The deposit's central ridge was composed of sand and shell and was exposed on some parts. Tidal flats were 1.75 ha in extent and were present at the edges of the adjacent marsh. The dredged material island study area consisted of two connected areas. The southern one was elongate on a south-to-north axis and was chiefly dense grassland on the higher portions, with a shrub thicket between it and the salt marsh. The second area was a low rise on the northern end of the upland portion of the island. It was chiefly dense grassland, though rather sparse on top. A border of marsh elder occurred at many places where the upland met the salt marsh.

74. Island X27 was characterized by late seral stage vegetation (Appendix B) but early and mid seral stage vegetation was also present (Figure 13). The grassland on the south central portion was dominated

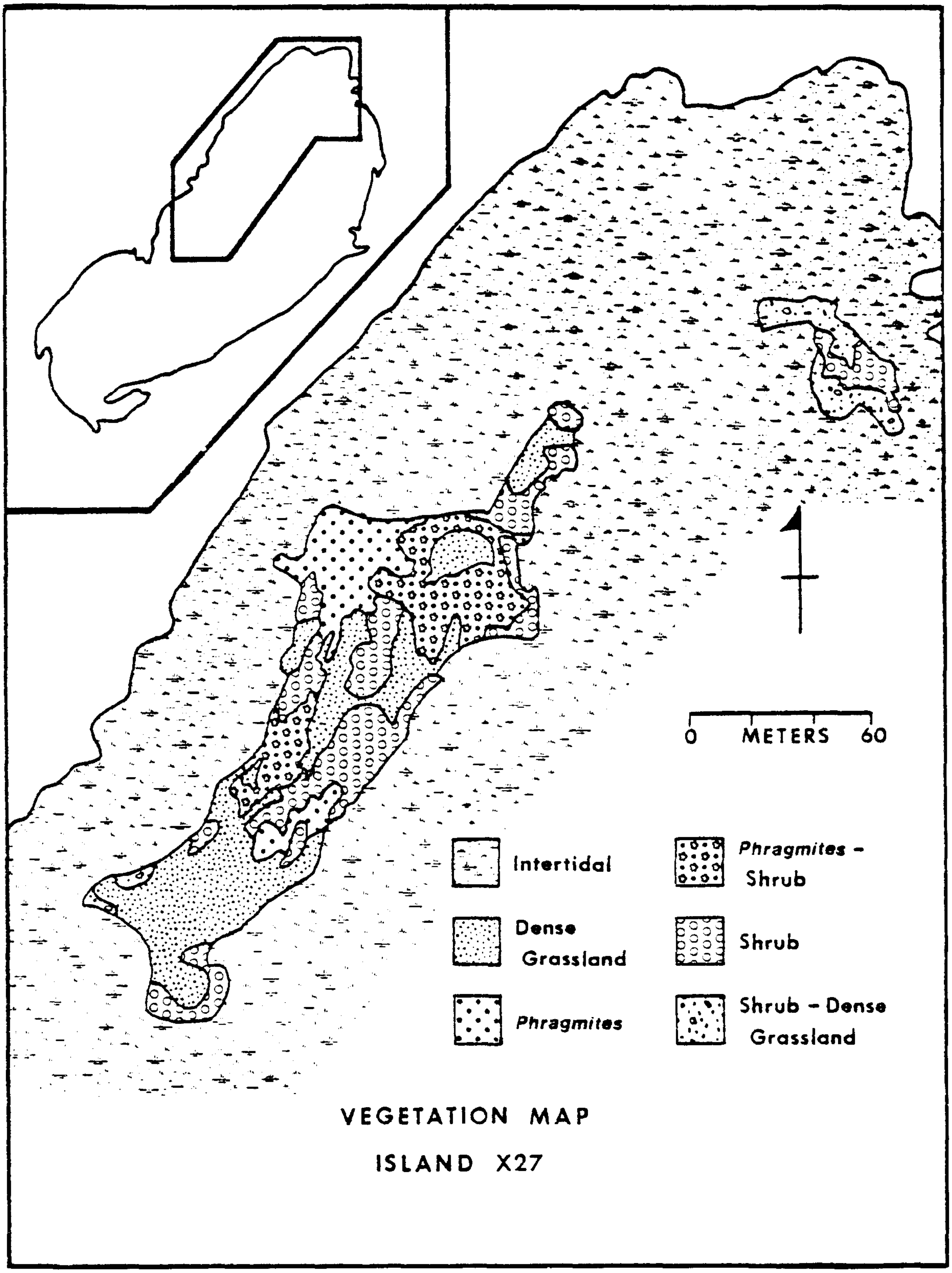

Figure 13. Vegetation map of Study Island X27

by American beachgrass, poor-man's pepper, and yarrow (*Achillea millefolium*). On the western side of the grassland was a shrub thicket with 2.0 to 4.0-m high groundsel and shorter marsh elder with abundant wild lettuce (*Lactuca biennis*) beneath. The shrub thicket on the east was dominated by groundsel and poison ivy, with wild lettuce and yarrow in the herb layer. Further to the south, patches of marsh elder met the dense grassland areas. On the northernmost end of the deposit area, the grassland was composed of poor-man's pepper, yarrow, American beachgrass, Canada thistle, seaside goldenrod, and beach-pea (*Lathyrus japonicus*). Marsh elder and groundsel separated the grassland from the high marsh.

75. Goosebar Sedge supported a mixed species heronry, as well as a herring gull colony and five pairs of great black-backed gulls (*Larus marinus*). The island had supported a heronry and herring gulls in 1976 (Kane and Farrar 1976). The birds were already on site during the May survey and all species had young, ranging from newly hatched to running, by the June survey. The herons were nesting in the common reed, reed-shrub, and shrub communities (Appendix B), but their nests were mostly in bayberry about 1.5 m high, many of which were dead or not fully leafed (Figure 14). The herring and great black-backed gulls nested in the dense grassland communities surrounding the base and periphery of the heronry. Many nests were at the base of marsh elder and groundsel shrubs less than 1.0 m high.

76. The nearest heron colony to Goosebar Sedge was located on Barrel Island (colony X47 on Figure C2), only 0.4 km away. The closest herring gull-great black-backed gull colony was located approximately 1.7 km away on Middle Island (colony 25, Figure C2).

Study Island 51B, Shooting Thorofare

77. Island 51B (Shooting Thorofare) is an irregularly shaped, rectangular, undiked dredged material island. Located in Ocean County at 39° 31' N and 74° 18' W, it is in the Tuckerton marshes directly opposite Beach Haven Inlet and 0.3 km from the New Jersey Intracoastal

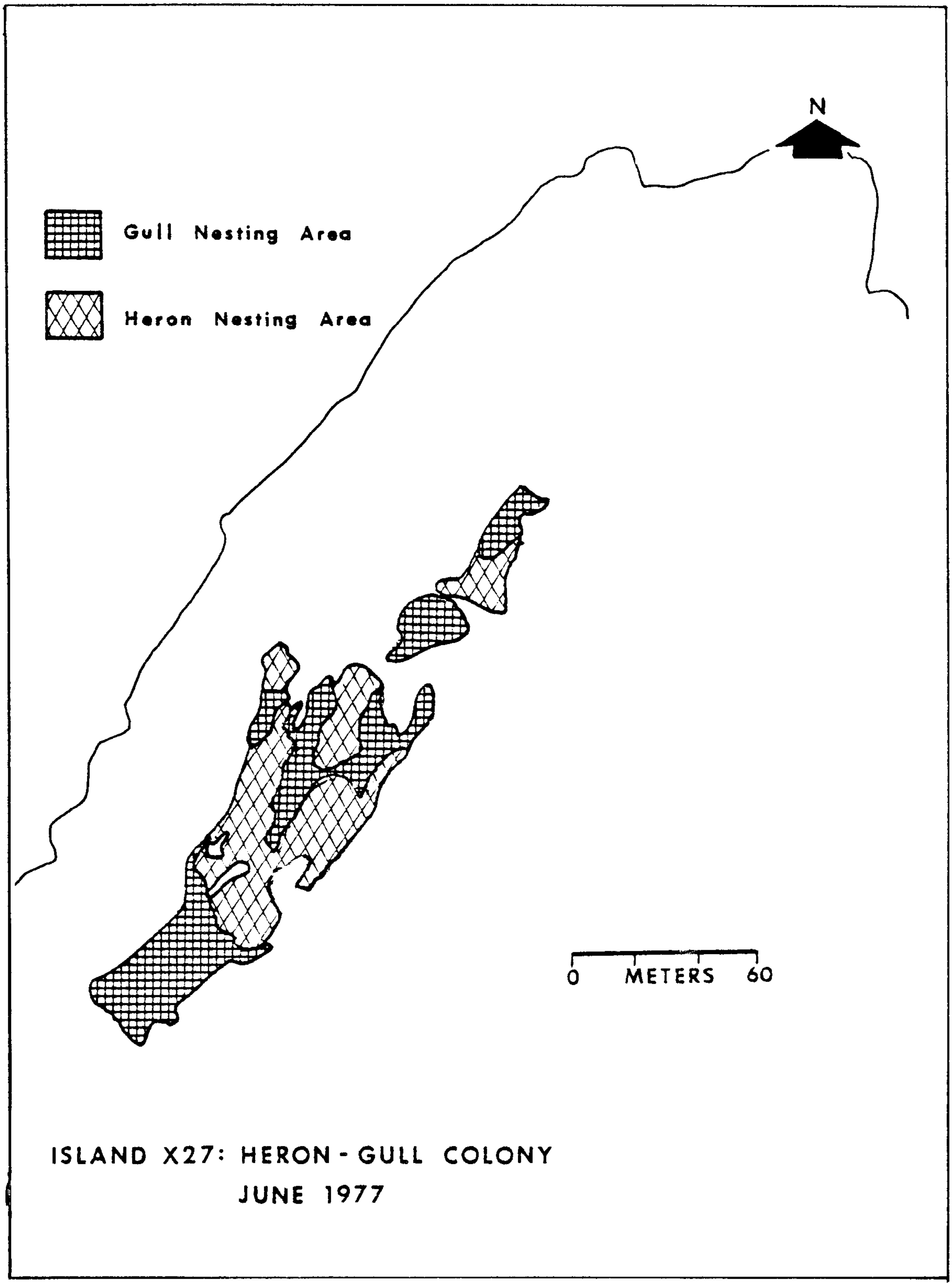

Figure 14. Map of heron-gull colonies on Study Island X27

Waterway. The island size was estimated to be 17 ha, with a dredged material deposit 1.8 ha in size. The dredged material deposit on Island 51B was placed in 1965 upon a large area of salt marsh, which extends about 7.2 km from Tuckerton. The dredged material deposition was basically rectangular in shape, with a cutoff pattern to the arching vegetation zone, suggesting that the deposit was subject to erosion. Sides of the surrounding salt marsh were badly eroded by wave action.

78. Vegetation was characteristic of an early seral stage, though mid seral stage vegetation was also present. Much of the marsh surface was non-vegetated peat and salt panne. Drift material left by storm tides was found partway up the deposit dome. On the dome (Figure 15) seaside goldenrod, tumble grass, and small fleabane (*Erigeron pusillus*) were the most abundant plants. The base of the dome was predominantly of American beachgrass. On the south this gradually descended to a mixture of common reed that was 1.0 to 1.5 m tall and growing above an American beachgrass layer. Bayberry shrubs were scattered throughout, and a large area of drift was beneath some of the sparser reed areas. The northern side had a similar mixture of reed, low grasses,and herbs but with abundant bayberry and groundsel scattered throughout. The western side had a high marsh with a mixture of common reed on the upper edge. The marsh was frequently bordered by marsh elder, common reed, and groundsel.

79. While Island 51B did not support any nesting colonies of seabirds or wading birds in 1977, it may have in the past. Common terns and black skimmers nesting on the barrier beach at nearby Holgate were forced to leave there because of rat predation. About a year after Island 51B received dredged material deposition (1965) these species were believed to be using this site (personal communication, October 1977, W. Shoemaker and R. Mangold, Department of Environmental Protection, Trenton, NJ) for nesting. The birds have since returned to Holgate to nest (Appendix A).

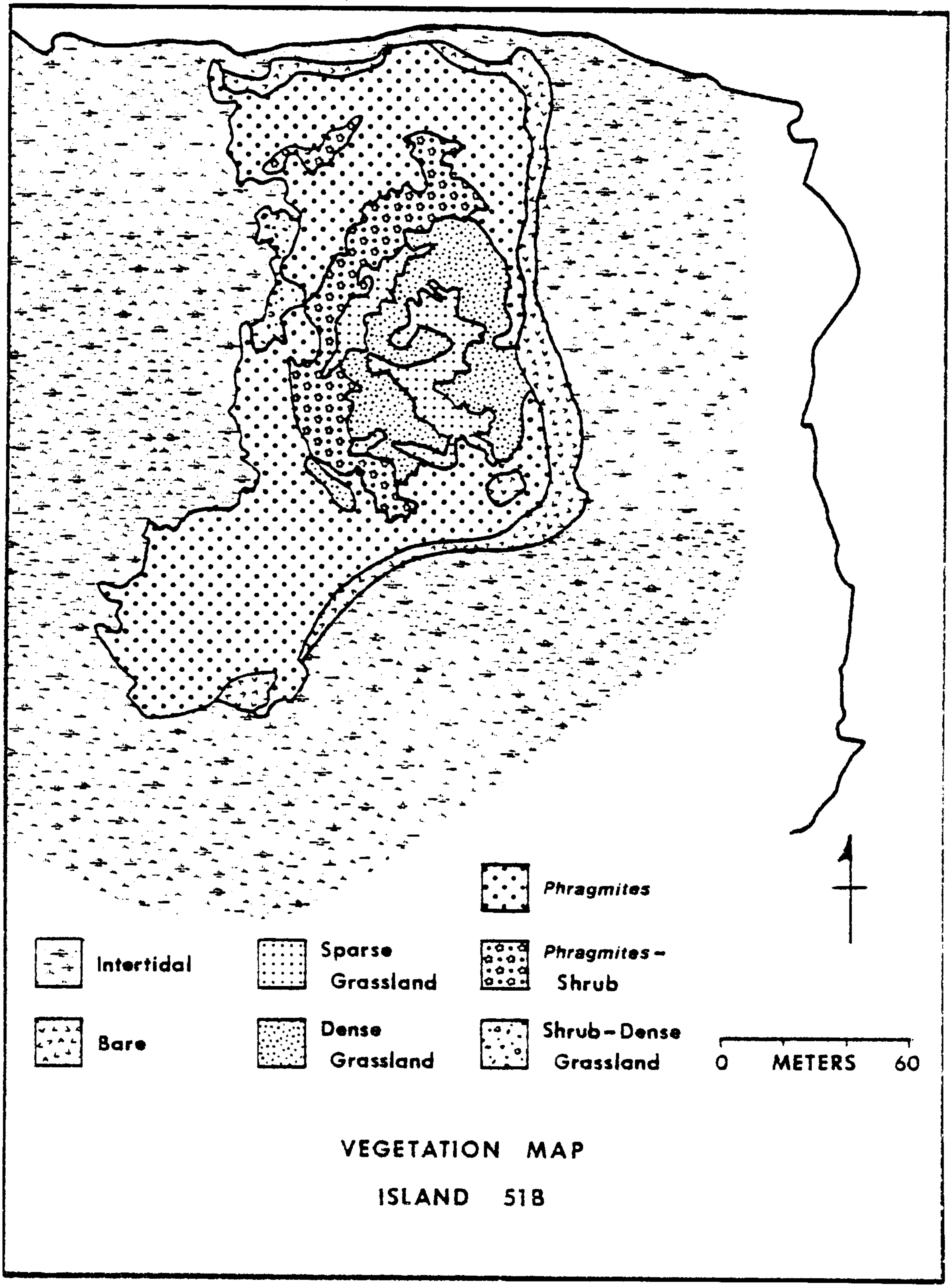

Figure 15. Vegetation map of Study Island 51B

Study Island A61c, Little Heron Island

80. Island A61c (Little Heron Island) is a circular, undiked dredged material island. Located in Atlantic County at 39° 24' N and 74° 26' W, it is about 5.2 km northwest of Absecon Inlet and 0.12 km from the New Jersey Intracoastal Waterway. Island size is approximately 5.5 ha with a 3.5 ha dredged material deposit. The date of the last dredged material deposition is unknown, but was probably prior to 1969. Tidal range on the island is 1.03 m and the island is surrounded by extensive salt marsh. Island elevation is approximately 1.0 to 1.5 m.

81. Little Heron Island was characterized by early seral stage vegetation and was dominated by a large stand of 2.4-m high common reed. Mid and late seral vegetation were also present, and live and dead groundsel were scattered throughout the common reed. Seaside goldenrod and poor-man's pepper were common in places beneath the reed. On the eastern side of the dredged material was an arc which had a lower vegetation cover. By aerial view it appeared to be a ridge vegetated by grasses, reed, and scattered bayberry (Figure 16). Some of the outer parts of the dredged material had 0.5 to 3.6-m high shrub thickets, composed mostly of bayberry, groundsel, and marsh elder, with an abundance of orach and common reed.

82. On the western side of the island the vegetation was more marsh dominated. The upper part of the salt marsh was bordered by marsh elder with black grass (*Juncus gerardi*), red fescue grass, and saltgrass (*Distichlis spicata*) carpeting most of the ground. Drift mats were also present in this area. Between the marsh elder and the common reed was an arc of essentially bare salt panne surrounded by high marsh, composed chiefly of saltgrass and black grass. In one location there was a ridge about 0.5 m above the marsh surface vegetated by a 3.6-m high shrub thicket and dominated by bayberry and marsh elder with scattered reed. The herb layer consisted of orach, saltgrass, saltmeadow cordgrass, and pigweed (*Chenopodium album*).

83. Little Heron Island supported one of the largest mixed species heronries and herring gull colonies in New Jersey in 1977. The island

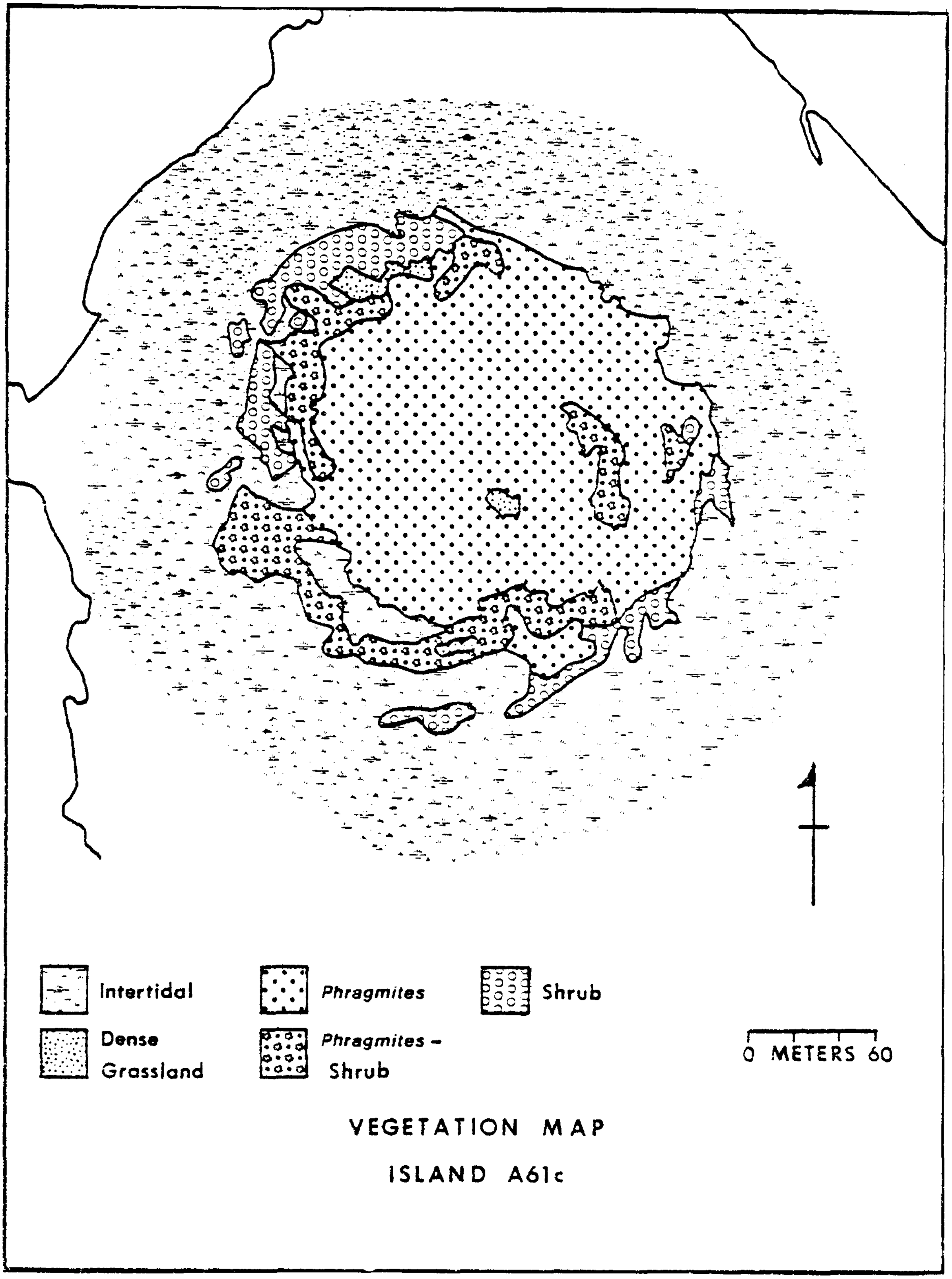

Figure 16. Vegetation map of Study Island A61c

has been the site of a heronry since at least 1959 (Adams and Miller 1975) and of a herring gull colony since at least 1974 (Burger 1977b). All of the herons nesting in New Jersey except great blue herons (*Ardea herodias*) and green herons (*Butorides striatus*) were found in this colony. However, yellow-crowned night herons (*Nyctanassa violacea*) present in May, were not observed in June at the colony site. During the May survey all species had eggs, and by June 7 young were present in and out of their nests. The herons occupied most of the upland portions of the study island and were found in common reed and common reed-shrub vegetation communities (Figure 17). Although they nested in the reed, many nests were placed in live and dead bayberry and groundsel scattered through the reed.

84. The gull colony was located on the periphery of the heronry, with the gulls nesting in a wide variety of vegetation communities (Figure 17): dense grassland, common reed, common reed-shrub, shrub, and intertidal. While most nests seemed to be at the base of low marsh elder and groundsel shrubs, a preferred site in more crowded colonies (Burger 1977a), many were also in the wetter areas of the intertidal zones and on bare sand. There were six pairs of great black-backed gulls scattered among the herring gulls. They were more advanced than the herring gulls since only young and no nests were found in June. The nearest heronry and gull colony to Little Heron Island was only 1.2 km north at Islajo (colony A61b, Figure C2), another dredged material island very similar to A61c and adjacent to the New Jersey Intracoastal Waterway.

Study Island A59a, Perch Cove Point (Big Shad)

85. Island A59a (Perch Cove Point) is also called Big Shad. It is a circular, undiked, dredged material island within the boundaries of Brigantine National Wildlife Refuge. Located in Atlantic County at 39° 28' N and 74° 24' W, it is west of Brigantine Inlet and adjacent to the New Jersey Intracoastal Waterway. The dredged material portion of the island is nearly 2.4 ha in size and at the tip of a salt marsh

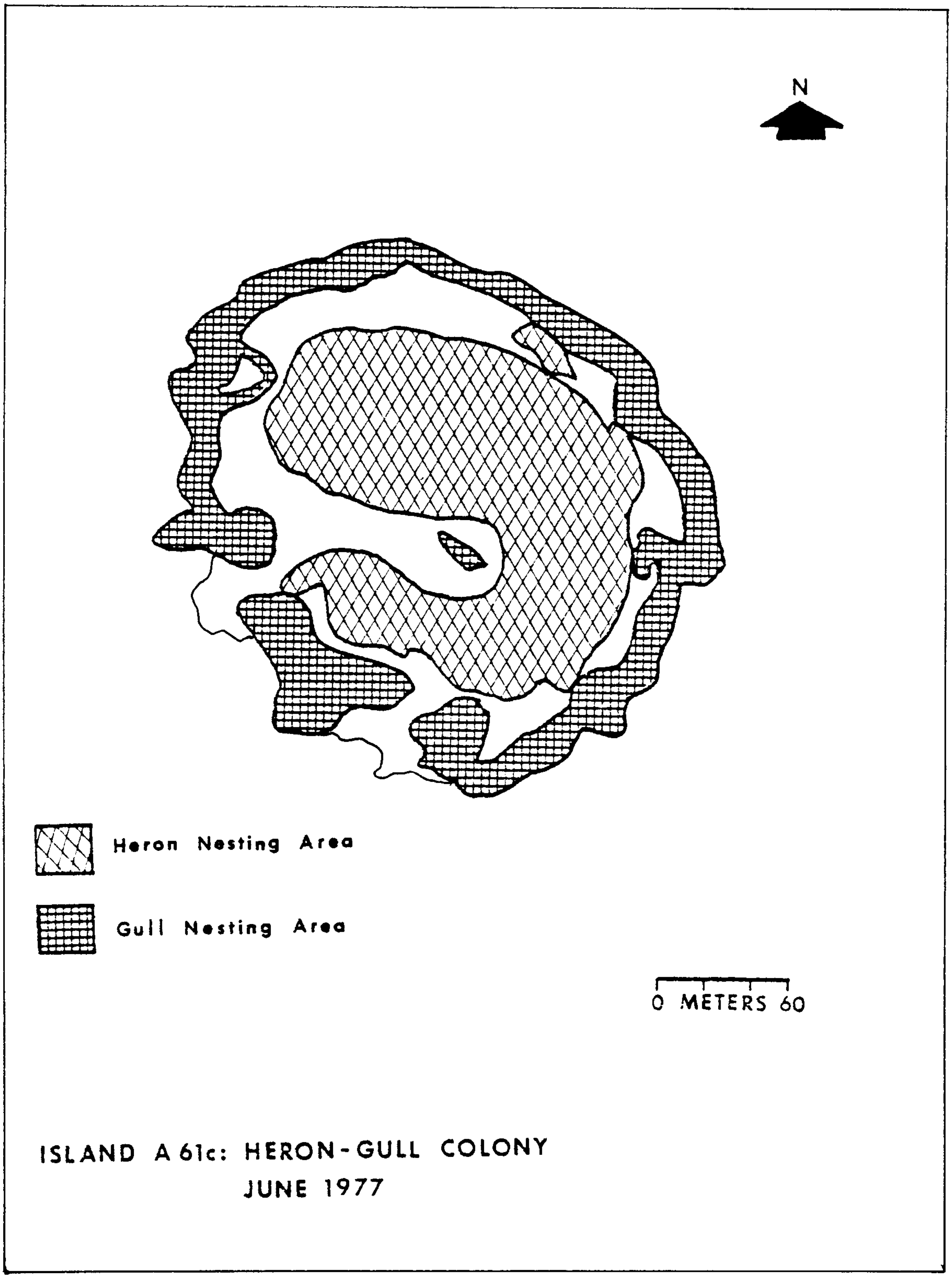

Figure 17. Map of heron-gull colonies on Study Island A61c

abutting Perch Cove. The tidal range at the site is 1.03 m and the island's elevation is estimated to be not more than 1.0 m. Tidal flats (1.2 ha) are adjacent to the dredged material deposit. Despite the presence of early and late seral stage vegetation, the study island was dominated by mid seral stage vegetation communities (Appendix B).

86. The perimeter of the dredged material deposit was covered by a large bare salt flat beyond which there was an expanse of salt marsh. A narrow band of salt marsh also surrounded the upland vegetation. The high marsh vegetation mixed with marsh elder and gradually ascended to a mixture of 2.0-to 4.0-m-high common reed, bayberry, groundsel, and marsh elder. Common reed dominated this association on most of the island. On the eastern side, and at one place on the west side, 4.0-to 6.0-m high shrubs dominated the reed. Several 1.8-to 3.6-m-high shrub thickets were located throughout the island. The shrub thickets were dominated by bayberry and groundsel, though poison ivy and common reed were also present. A few red cedar (*Juniperus virginiana*) trees, 3.0 to 4.6 m high, also grew in the thickets (Figure 18).

87. Perch Cove was selected as a vegetation study island, but it had herons nesting or attempting to nest on it in May 1977. Although not previously recorded as a seabird or wading bird nesting colony site, 20 pairs of black-crowned night herons (*Nycticorax nycticorax*) were nesting. On 3 June, a few black-crowned night herons were still present along with a pair of yellow-crowned night herons (Kane and Farrar 1977). By June and thereafter there was no sign of the birds. It is possible that their young had fledged by this time (Appendix A), or that the birds had deserted the island after predation or human disturbance. The part of the island on which the birds were found was an area of mixed shrubs and common reed with abundant, very high poison ivy intermixed with the other species.

Study Island 85dmi, Weakfish Creek

88. Island 85dmi (Weakfish Creek) is a circular, undiked dredged material island. Located in Cape May County at 39° 13' N and 74° 39' W,

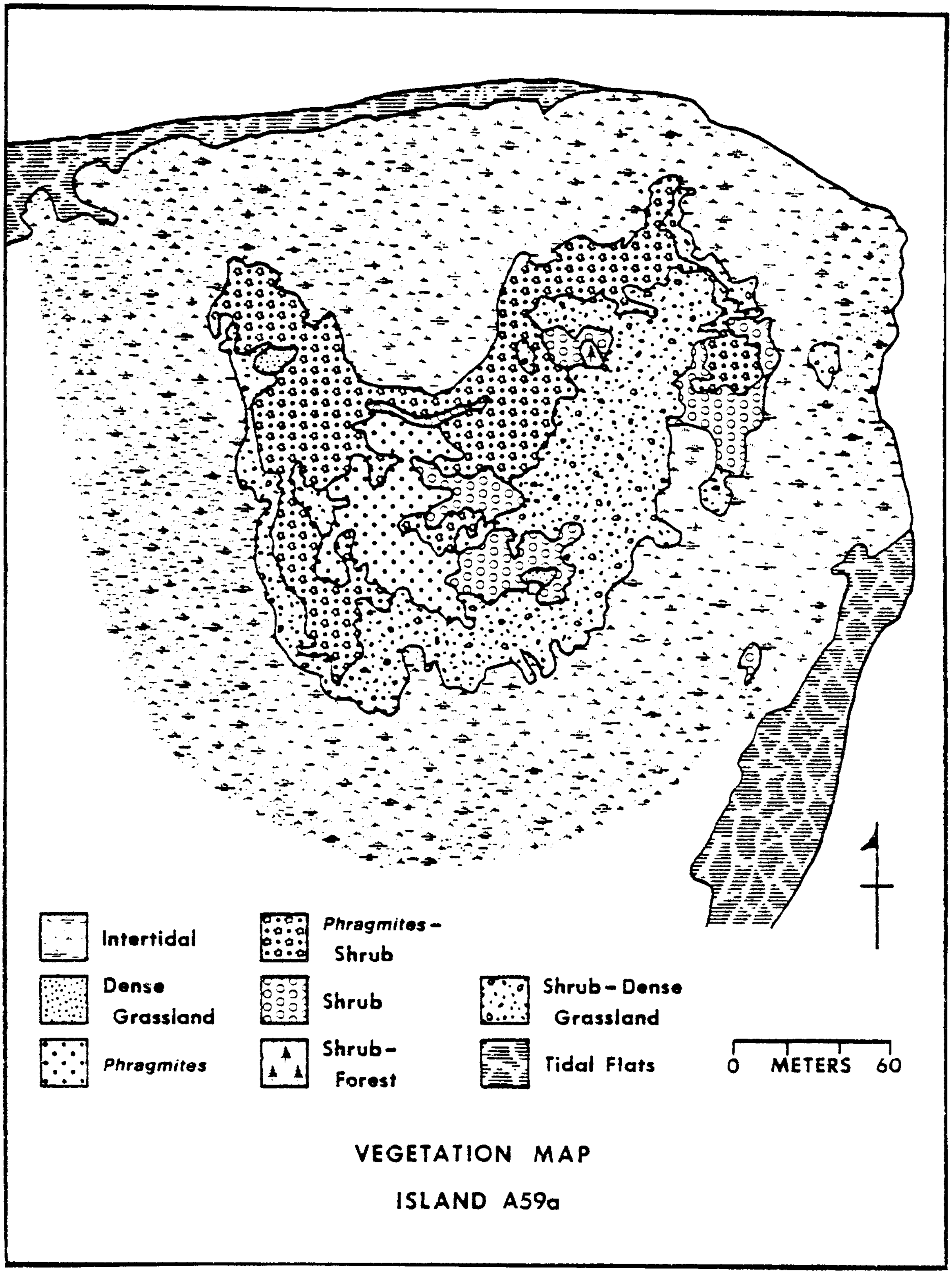

Figure 18. Vegetation map of Study Island A59a

it is northwest of Corson's Inlet, south of the junction of Beach Creek and Weakfish Creek, and adjacent to the New Jersey Intracoastal Waterway. It is a salt marsh area which had dredged material deposited upon it in 1966. The dredged material deposit area was approximately 2.4 ha on an island that was 3 ha in size and surrounded by extensive salt marsh. Houses were nearby on the barrier beach. Tidal range on this island is 1.1 m. It is a fairly low, flat island with elevation estimated at less than 1.0 m. Vegetation was characteristic of a late seral stage but early and mid seral stage vegetation was also present.

89. Most of the dredged material deposit area was vegetated by shrubs and common reed. A wide belt of marsh elder with a herb layer of saltmeadow cordgrass, red fescue grass, and several other plants including some halophytes was present. The northwestern tip of the dredged material was dominated by common reed. In many places shrubs mingled with the reed. These included 2.0 to 4.0-m high bayberry, poison ivy, and a small amount of elderberry (*Sambucus canadensis*), groundsel, and red cedar. On the marsh side, marsh elder was associated with common reed. Here black grass and saltmeadow cordgrass formed the ground cover. There were some areas in which the shrubs dominated the reed, and in others the reverse was true. Besides the reed-shrub associations, the shrub thicket itself was very important. This included bayberry, groundsel, marsh elder, occasional red cedar, and some 1.0 to 2.0-m high reed. (Figure 19).

90. Weakfish Creek supported a much larger heronry in May 1977 than it did in either June 1976 (Appendix A) or June 1977. In May 1977 there were 75 snowy egrets (*Egretta thula*), 45 black-crowned night herons and two cattle egrets (*Bulbucus ibis*) nesting on the island. By 6 June 1977, no cattle egrets were found but glossy ibises (*Pledagis falcinellus*) were present. The herons were nesting in the shrub community with most nests in bayberry as high as 4.5 m (Figure 20). The nearest heronry to Island 85dmi was at Cowpens Island (colony A80a, Figure C2), a distance of about 8.85 km.

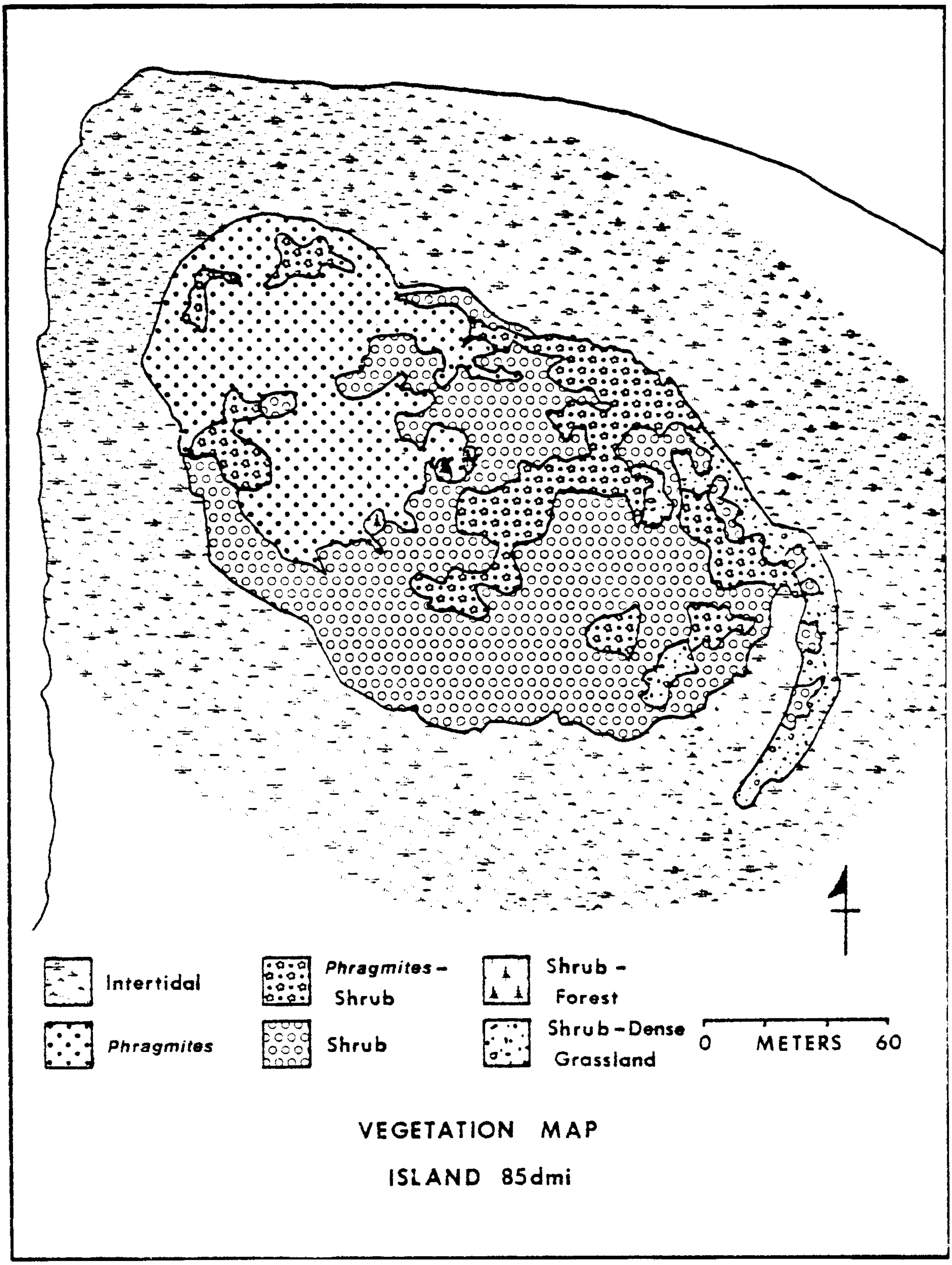

Figure 19. Vegetation map of Study Island 85dmi

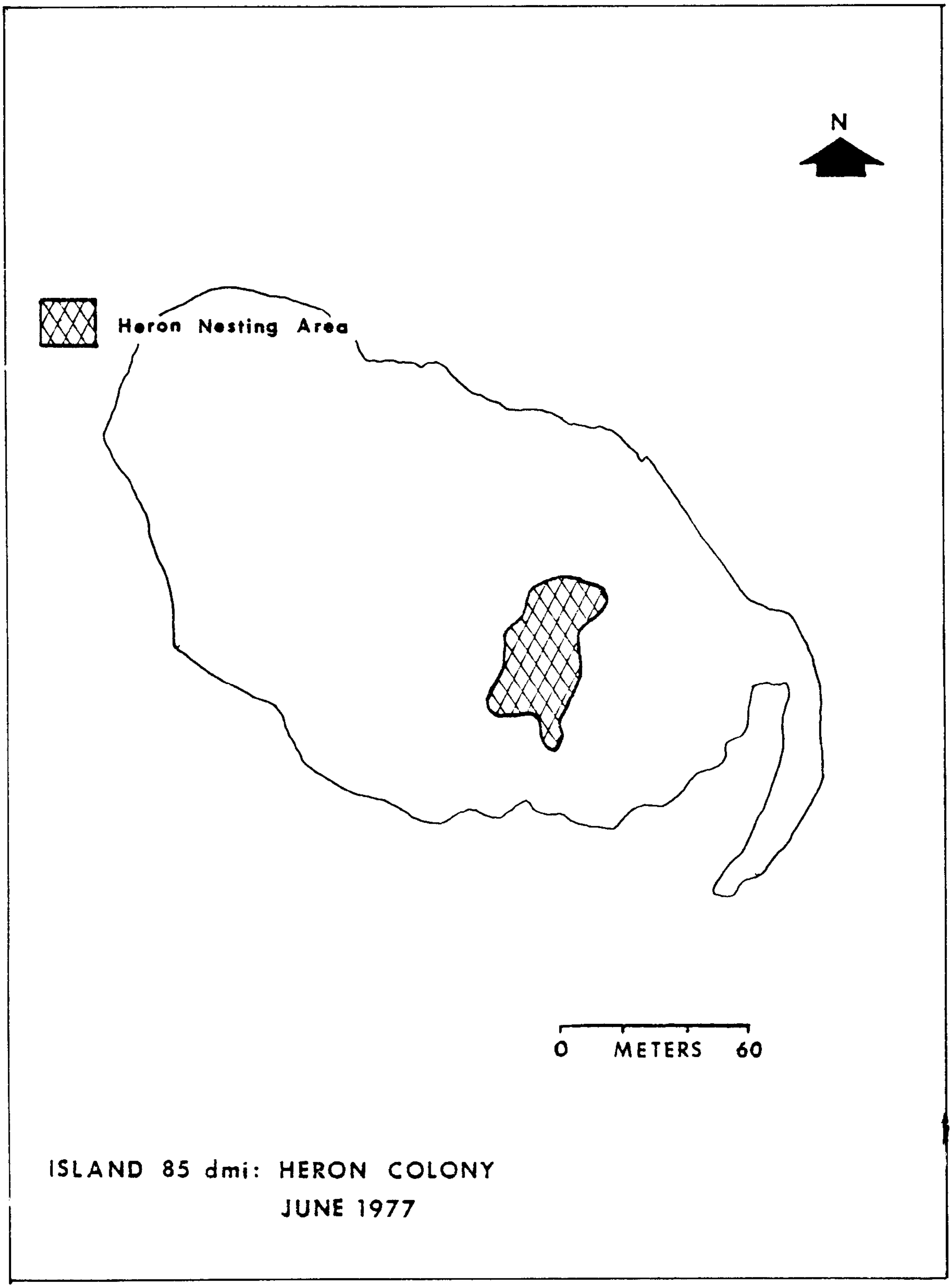

Figure 20. Map of heronry of Study Island 85dmi

Study Island 85 South, Middle Thoro

91. Island 85 South (Middle Thoro) is a circular, undiked dredged material island located in Cape May County at 39° 15' N and 74° 39' W. It is adjacent to the New Jersey Intracoastal Waterway, less than 1.0 km from the barrier beach, and about the same distance northwest of Corson's Inlet. It is south of Study Island 85dmi and separated from it by salt marsh, creeks, and another small dredged material deposit. The 0.9 ha dredged material deposit on 85 South (13.6 ha) was last used for dredged material deposition in 1966. The island has a tidal range of 1.1 m and is fairly flat with an elevation of approximately 0.5 m at the center of the dredged material deposit area. Vegetation was characterized by a late seral stage, though plant communities indicative of mid-seral stages were also present (Appendix B).

92. A ring of salt pannes extending from the low salt marsh bordered the dredged material deposit. The periphery of the upland area was dominated by an open area of marsh elder 1.0-m high and with a dense ground cover of high marsh species dominated by black grass. Scattered common reed was found with the black grass. A band of 1.0 to 1.5-m high reed, mixed with equal height marsh elder, groundsel, and bayberry, with black grass and red fescue grass dominating the herb layer inside the periphery. Shrubs, dominated by 2.0 to 3.9-m high bayberry and marsh elder covered the center of the deposit area. Reed was scattered through the shrub thickets. Winged sumac (*Rhus copallina*) and poison ivy were also common. Occasional 2.0 to 4.0-m high red cedars were also present (Figure 21).

Study Island 98A, Sturgeon Island

93. Island 98A (Sturgeon Island) is an elliptically shaped, undiked dredged material island located in Cape May County at 39° 05' N and 74° 46' W. It is 6.4 km northwest of Hereford Inlet, about 6 km southwest of Townsend's Inlet, and 0.20 km from the New Jersey Intracoastal Waterway. Island size was approximately 5.9 ha and dredged

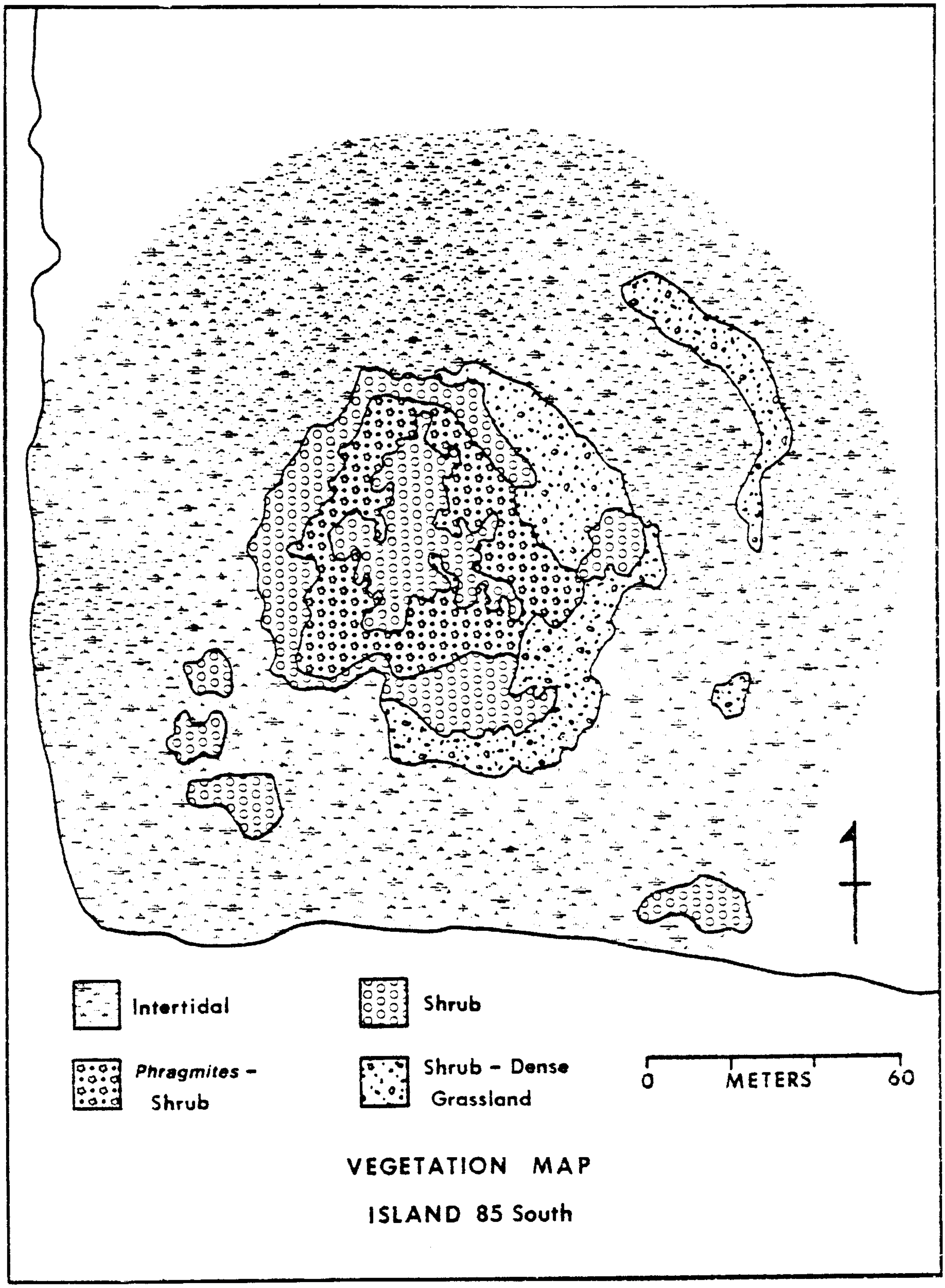

Figure 21. Vegetation map of Study Island 85 South

material covered about 0.8 ha of it. The last known dredged material deposition upon this island occurred in 1968. Tidal range on the island is 1.3 m, and there is 5.1 ha of tidal flats adjacent to the dredged material deposit. The island is low and fairly flat with an elevation less than 1.0 m. Vegetation is characterized by a mid seral stage, but early and late seral stages are also present (Appendix B).

94. The western side of the upland portion of the dredged material island is mostly high marsh dominated by a lush carpet of saltmeadow cordgrass and saltgrass surrounded by a ring of high tide drift. On the upper end of the high marsh, drift left by spring tides or storm flooding rested at the border of shrub communities and the high marsh. This high marsh hooked in between two rows of shrubs (Figure 22). Marsh elder grew in the high marsh and upon the drift, forming the outer border of dredged material uplands with the marsh on the western side. On the eastern side, a 1.0 to 3.0-m high reed-shrub association dominated. Common reed, bayberry,and groundsel were the most common members of this association. On the marsh side and still within this community, marsh elder was an important component. A small area of bayberry-groundsel shrub thicket was located on the southeast. Another small shrub thicket containing one 2.4-m high red cedar was centrally located near the hook of the high marsh.

95. Sturgeon Island supported a colony of herring gulls that was unknown before May 1977. There were a few pairs of great black-backed gulls nesting, and a dozen pairs of laughing gulls were nesting on adjacent marshes. The herring gulls and great black-backed gulls nested on the upland portions of the island (Figure 23). Their nests were located in reed-shrub, shrub, and shrub-dense grassland communities, mostly on dense grassland, and were well hidden among poison ivy and low shrubs less than 1.0 m in height. Their nesting area surrounded an open grassy area used by them for loafing and preening. There were numerous pathways through the grass and shrubs created when the gulls trampled the vegetation on their way to and from their nests. While there were numerous chicks running about the colony site on 6 June 1977, several nests still had eggs. A green heron may have been nesting on

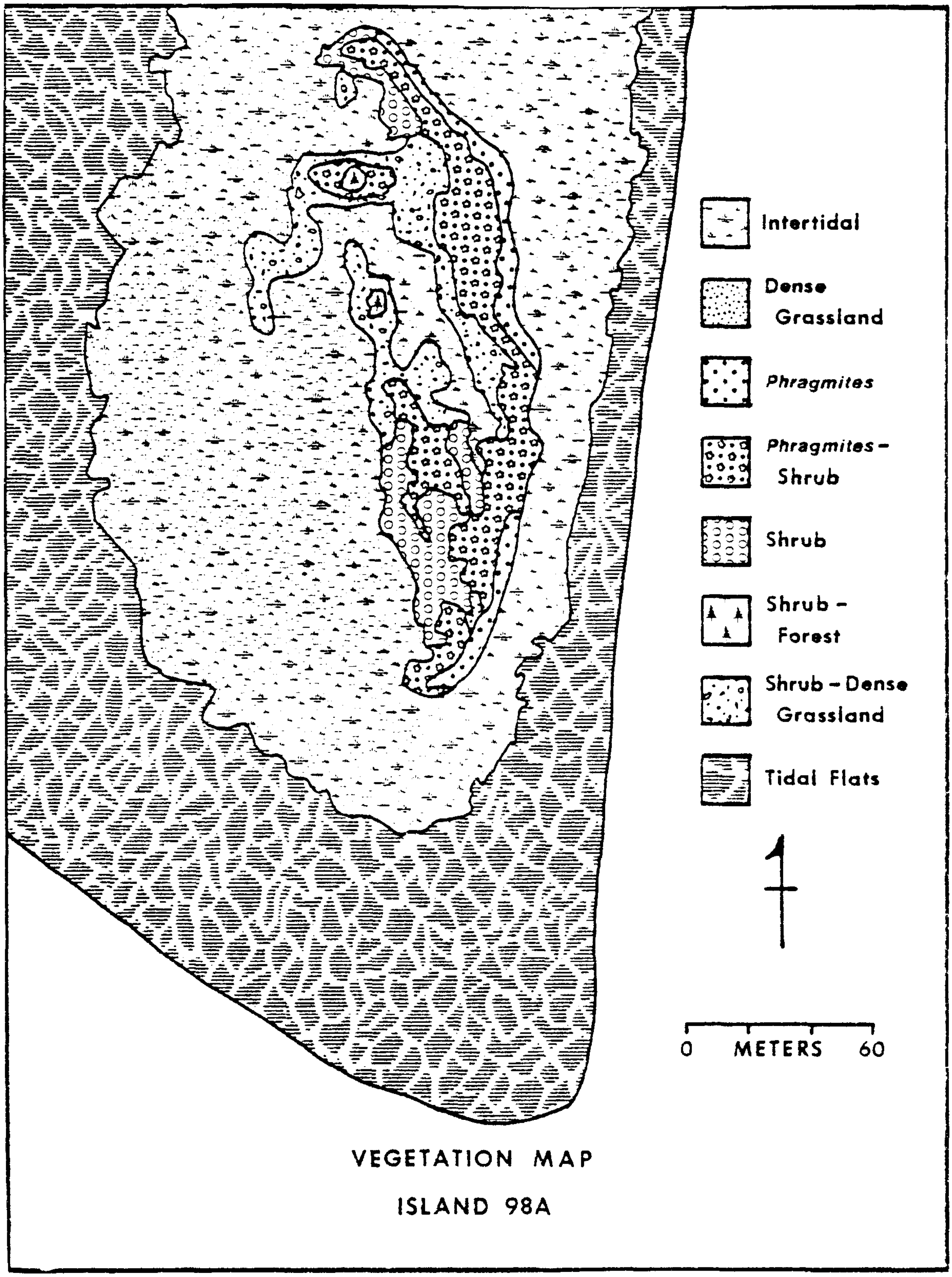

Figure 22. Vegetation map of Study Island 98A

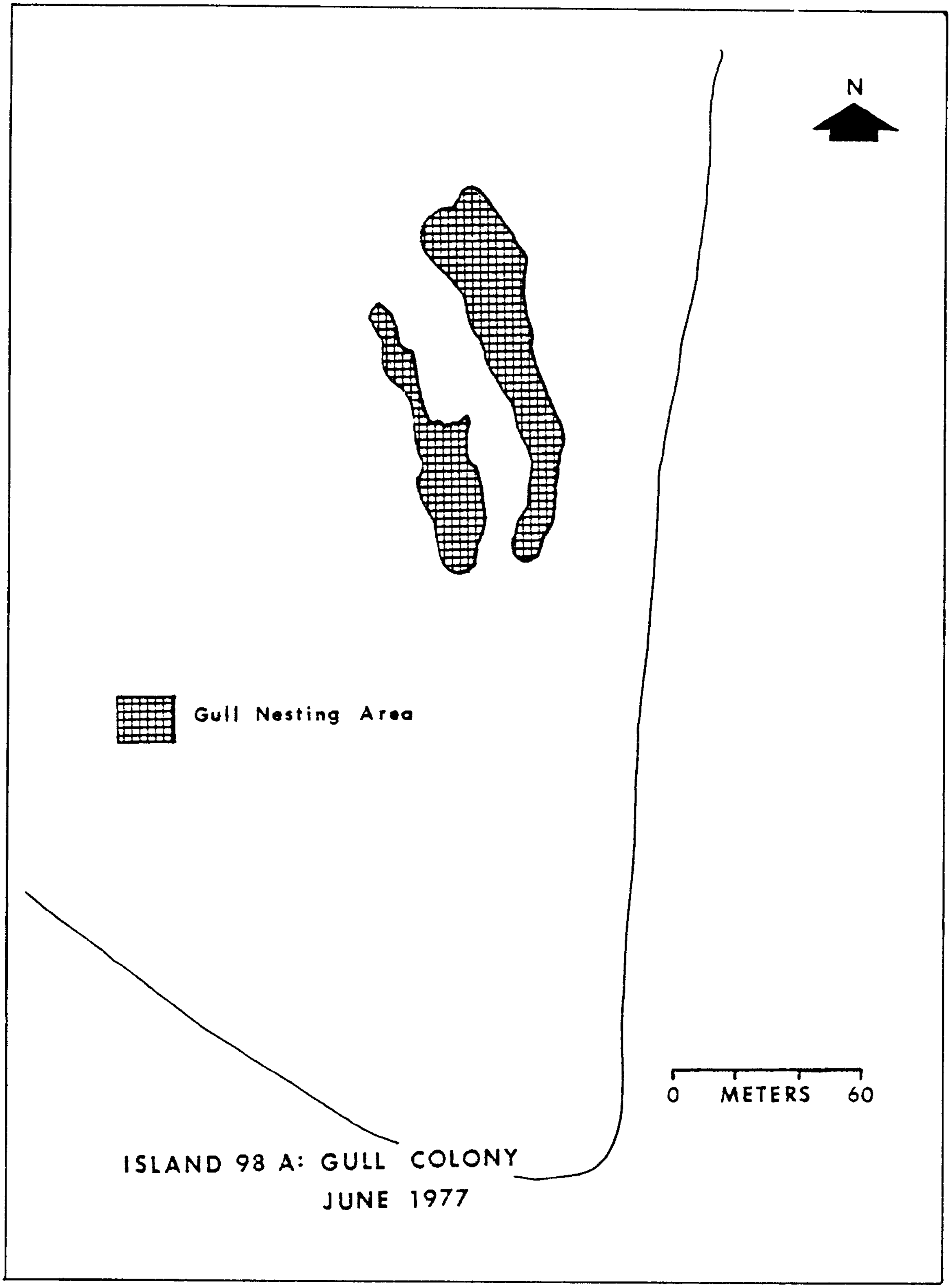

Figure 23. Map of gull colony on Study Island 98A

the island since it was observed roosting several times in a 2.4-m high red cedar. However, no nest was located. The nearest gull colony to Island 98A was located close by at Gull Island North (colony 98B, Figure C2), a distance of 0.68 km.

Study Island 108B

96. Island 108B is a triangularly shaped, undiked dredged material island also in Cape May County. Located at 39° 00' N and 74° 50' W, it is adjacent to the New Jersey Intracoastal Waterway and is about 3.2 km southwest of Hereford Inlet on the edge of Richardson Sound. The island is approximately 2.8 ha in size and the dredged material deposit upon it was approximately 0.2 ha. The island was last used for dredged material deposition in 1965. Its tidal range is 1.3 m and 0.2 ha of tidal flats are adjacent to the dredged material deposit. The island is fairly low and flat with an elevation under 1.0 m. Vegetation on Island 108B was characteristic of an early seral stage but mid seral stage vegetation was also present (Figure 24).

97. The island was surrounded by salt marsh and shallow water. The dredged material deposit was dominated by 1.0 to 2.0-m high stands of common reed. A band of marsh elder and orach was mixed with the reed The northern side of the deposit had a band of marsh elder and high marsh species dominated by saltmeadow cordgrass. The elder and reed sections were separated by a band of drift vegetation.

Study Island 98B North, Gull Island North

98. Island 98B North (Gull Island North) is a circular, undiked dredged material island in Cape May County. It is adjacent to the New Jersey Intracoastal Waterway and located 39° 05' N and 74° 47' W. It is about 6 km southwest of Townsend's Inlet and 6.4 km northwest of Hereford Inlet. The dredged material deposit area is about 0.5 ha on a 14.5 ha dredged material site. It was last deposited upon in 1968. Tidal range in this area is 1.3 m and 1.3 ha of tidal flats were adjacent

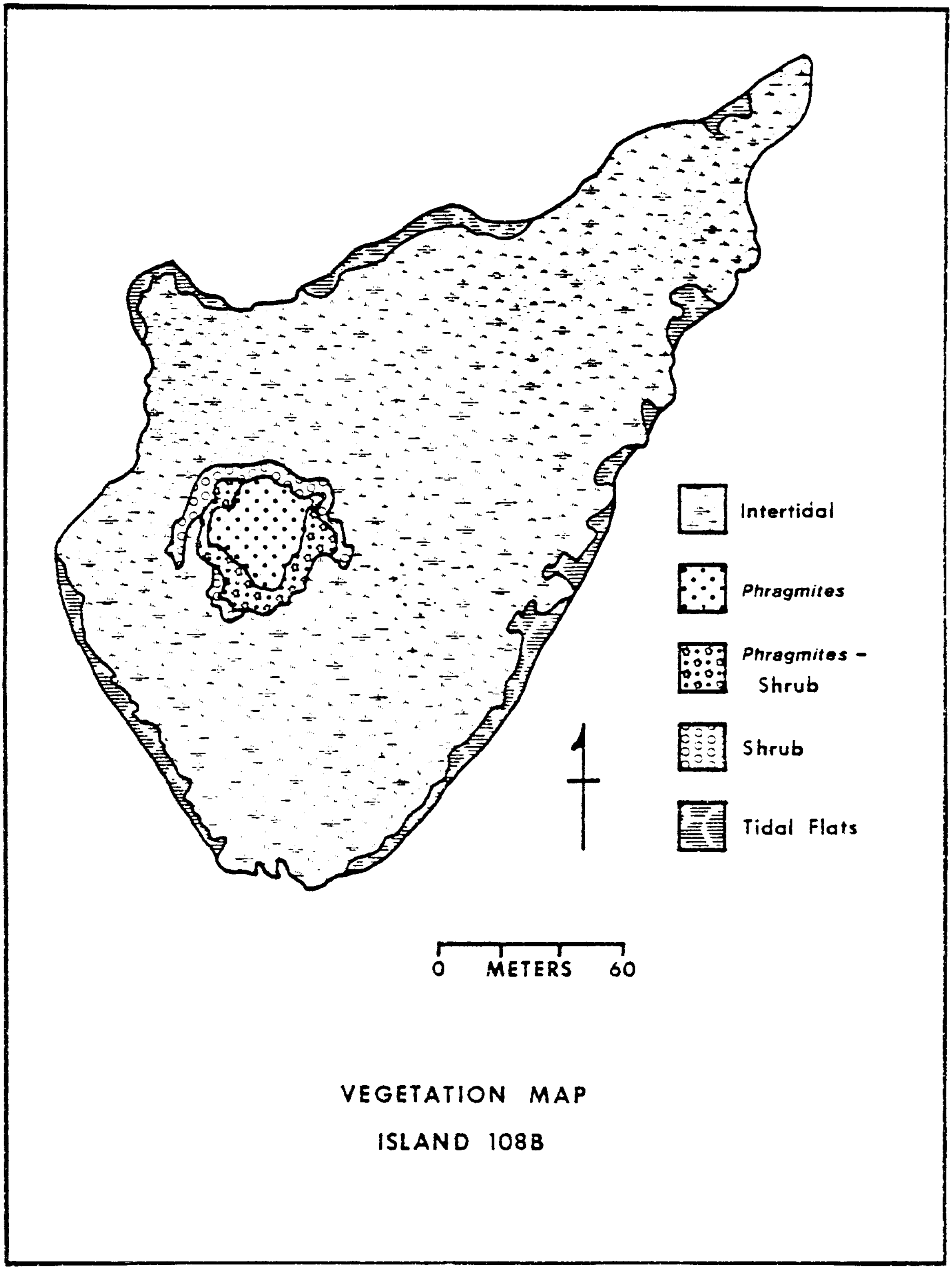

Figure 24. Vegetation map of Study Island 108B

to the dredged material deposit. Gull Island Islandis a fairly flat, low site and its elevation was less than 0.5 m. The dredged material deposit is surrounded by salt marsh and tidal pools which separate it from another dredged material deposit on the site directly south of it (98B South). Vegetation on Island 98B North was characterized by mid-seral stages though early and late seral stage vegetation was also present (Figure 25).

99. Less than 20 m of salt marsh separates the dredged material deposit from several large salt pannes in the upper marsh. The dredged material deposit was nearly surrounded by a mixture of marsh elder and a ground cover of high marsh species including saltmeadow cordgrass and black grass. Moving in towards the deposit center, an even mixture of marsh elder and common reed was abundant. This mixture gave way to a band of nearly solid common reed. The center of the island was a shrub thicket dominated by bayberry and groundsel. Reed was abundant and several 2.0 to 4.0-m high red cedar and black cherry (*Prunus serotina*) trees were also present.

100. Gull island North supported a mixed-species heronry and a small herring gull colony (Figure 26). This island was not a previously known colony site (Appendix A) and was discovered during the May 1977 survey. By 6 June 1977, some young were present but most heron eggs were beginning to hatch while the gulls had both eggs and young. The herons were nesting in reed, reed-shrub, and shrub-forest communities, with most of their nests in bayberry, groundsel, and marsh elder shrubs 1.5 to 3.0 m high. The herring gulls nests were at the periphery of the dredged material deposit and were in dense grasses very often at the base of low elder, goldenrod, and groundsel in a shrub vegetation community (Figure 26). The nearest heronry was 0.12 km away at Island 98B South (Gull Island South). The nearest gull colony was located on Sturgeon Island (98A), only 0.68 km away (Figure C2).

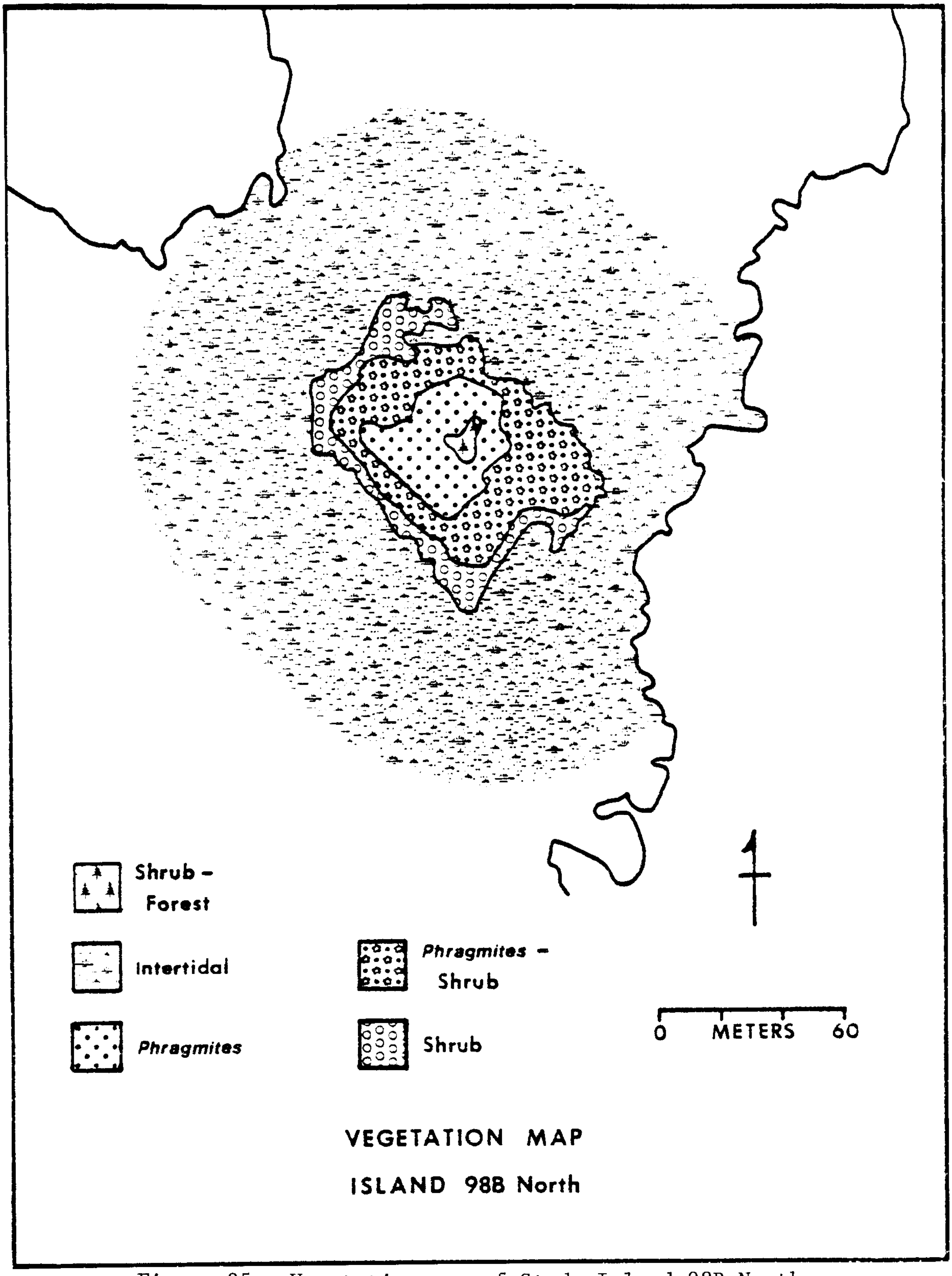

Figure 25. Vegetation map of Study Island 98B North

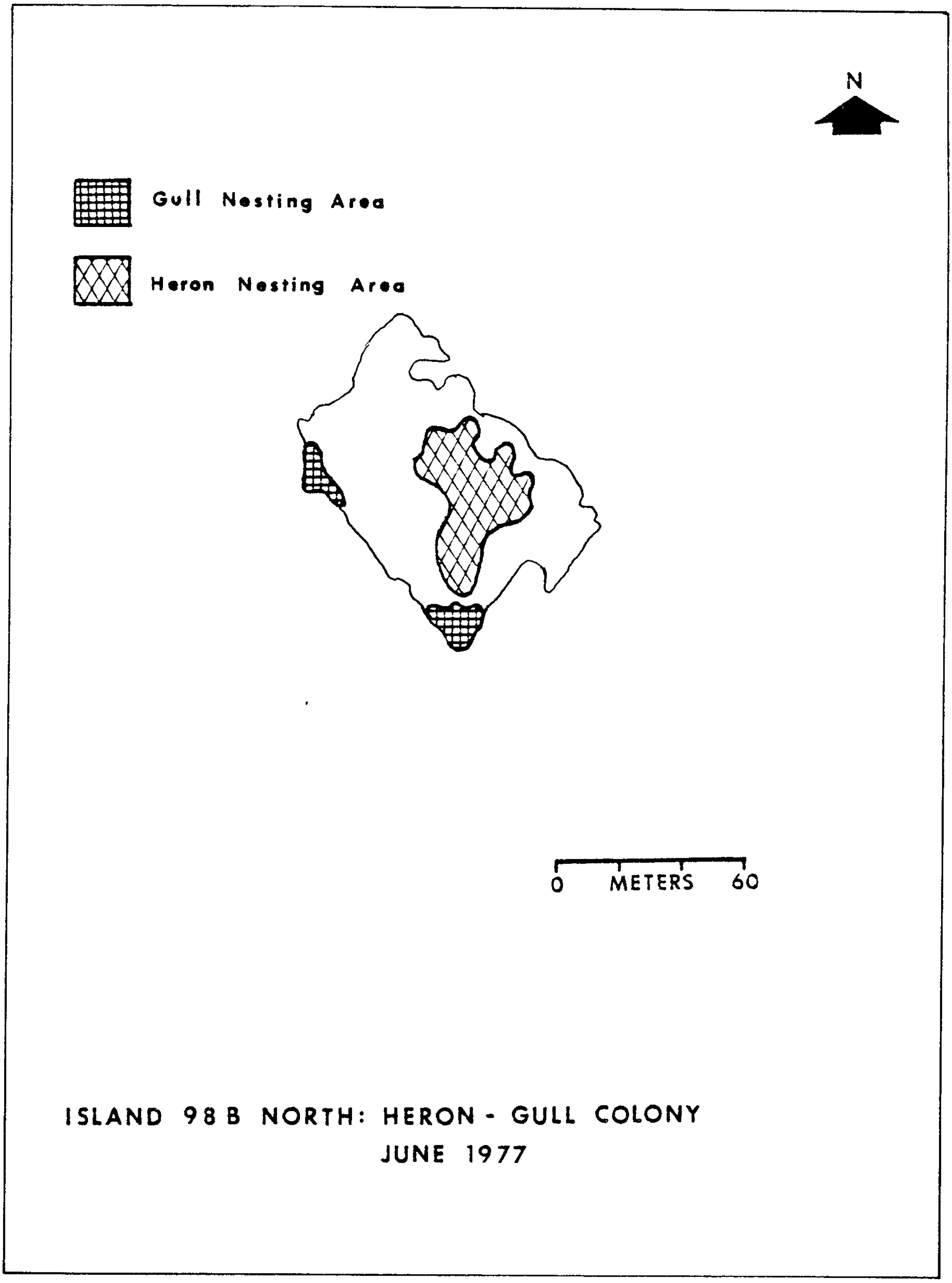

Figure 26. Heron-gull colonies on Study Island 98B North

Study Island 98B South, Gull Island South

101. Island 98B South (Gull Island South) is an undiked, circular dredged material island in Cape May County. It is adjacent to the New Jersey Intracoastal Waterway and located 39° 05' N and 74° 47' W. It is about 6 km southwest of Townsend's Inlet and 6.4 km northwest of Hereford Inlet. The dredged material deposit is 0.9 ha on a 14.5 ha dredged material site. It was last deposited upon in 1968. Tidal range in this area is about 1.3 m and 1.3 ha of tidal flats are adjacent to the dredged material deposit. Gull Island South is a fairly low, flat site and its elevation, while slightly higher than Island 98B North, is still under 0.5 m. Gull Island South is also surrounded by salt marsh, tidal flats, and shallow water. Vegetation on the island is characterized by a late seral stage; however, early and mid seral stage vegetation is also present.

102. This island was dominated by common reed, shrubs and red cedar. The area where marsh met upland was chiefly vegetated by saltmeadow cordgrass beneath marsh elder. A nearly pure stand of reed surrounded the perimeter of the uplant vegetation. Reed and elder in a reed-shrub association were in equal dominance on the southeast tip of the island (Figure 27). The center of the island contained a shrub thicket dominated by a 2.0 to 4.0-m high bayberry and 4.0 to 10.0-m high red cedar. Some reed, groundsel, and black cherry were also present here. In some areas, the vegetation was quite open and comprised of dense grassland dominated by switchgrass (*Panicum virgatum*), bluestem (*Andropogon scoparius*), red fescue grass, and poison ivy. In some areas the groundsel, common reed, winged sumac, and red cedar had invaded the dense grassland, though grassland species still comprised an herb layer. This island had more red cedar concentrated in one area than did any other island studied, although 78B South also had a large number of cedars.

103. Gull Island South supported a heronry that had not been previously known before May 1977 survey (Appendix A). Though black-crowned night herons were not observed on the 6 June 1977 census,

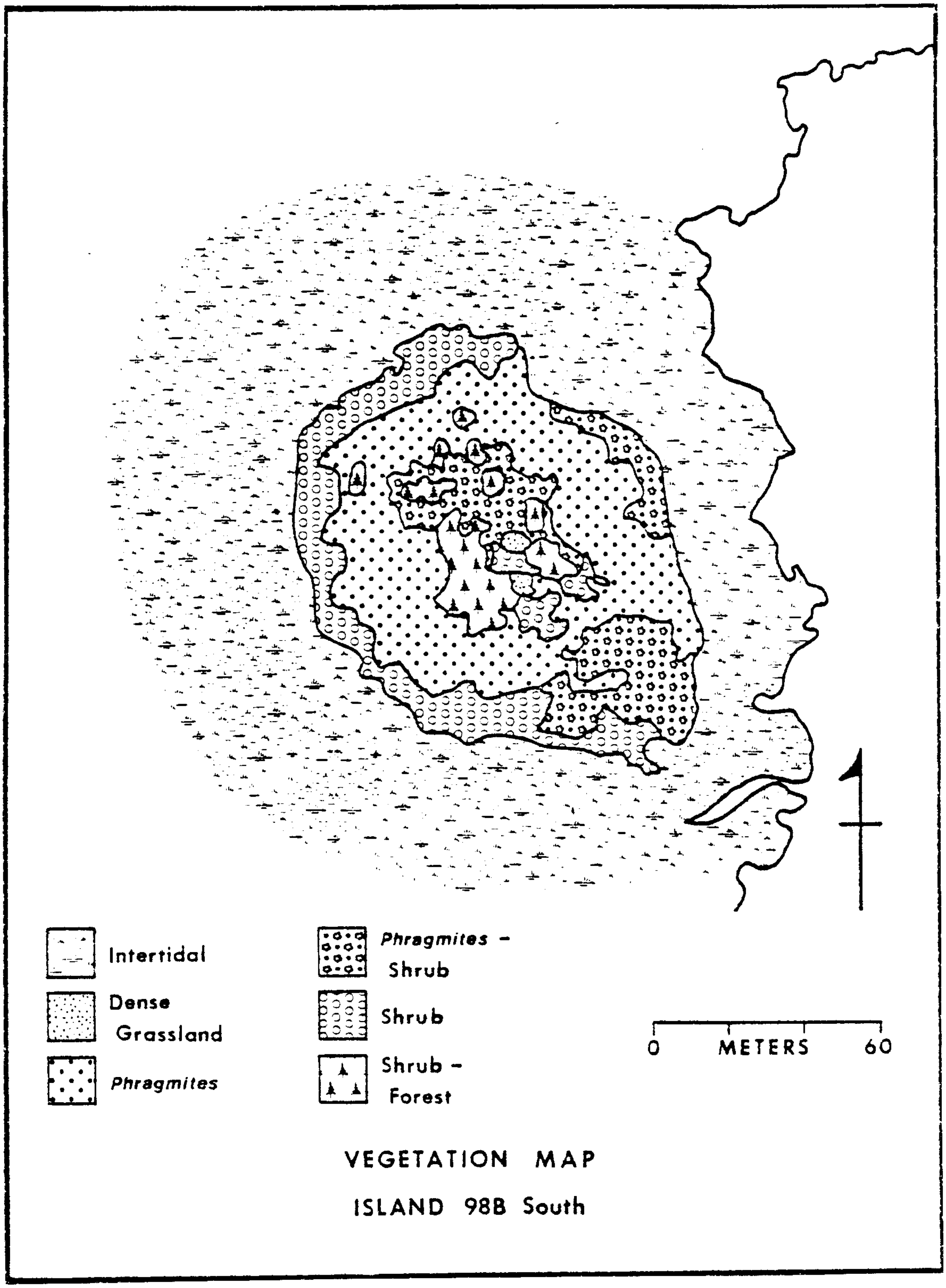

Figure 27. Vegetation map of Study Island 98B South

eight pairs had been found in May 1977 and four birds were seen on 8 June at the colony site. However, no black-crowned night heron nests were located. By 6 June 1977, young of other heron species were present in the colony. The nests were located in reed-shrub, shrub, and shrub-forest communities (Figure 28). Red cedar, groundsel, black cherry, and poison ivy seemed to be the preferred nest sites, although some nests were also found in common reed. The nearest heronry was 0.12 km away at Island 98B North.

Study Island 78B South, Broad Thorofare

104. Island 78B South (Broad Thorofare) is a linear, narrow, undiked dredged material deposit upon a salt marsh in Atlantic County. Located at 39° 19' N and 74° 34' W, it is 0.40 km from the New Jersey Intracoastal Waterway, 1.8 km from Somer's Point, and less than 2.7 km from Ocean City. The dredged material deposit, 3.4 ha, is placed upon a salt marsh estimated to be 50.9 ha in size. Another dredged material deposit, circular and undiked, is directly north of the study site and also part of Island 78B. Dredged material was last deposited in this area in 1969. Tidal range in this area is 1.2 m and estimated elevation of the dredged material deposit is 1.0 to 2.0 m. Vegetation on the dredged material study island is characterized by a late seral stage but early and mid seral stage vegetation is also present (Figures 29a and 29b).

105. The island was dominated by shrub thickets and a mixture of common reed and shrub species. The interior shrub thickets were about 2.0 to 4.0 m high and dominated by bayberry, poison ivy, and groundsel. Numerous red cedar trees, 3.0 to 6.0 m tall, were scattered through the shrub thickets. A few stands of reed were found on the island. Two types of dense grassland were also found: one was dominated by American beachgrass and the other by bluestem, seaside goldenrod, and yarrow. The salt marsh was bordered by 1.0 to 2.0-m high marsh elder, often with saltmeadow cordgrass beneath it. A mixture of sand and drift supported a varied vegetation on the seaward edge of the dredged material deposit.

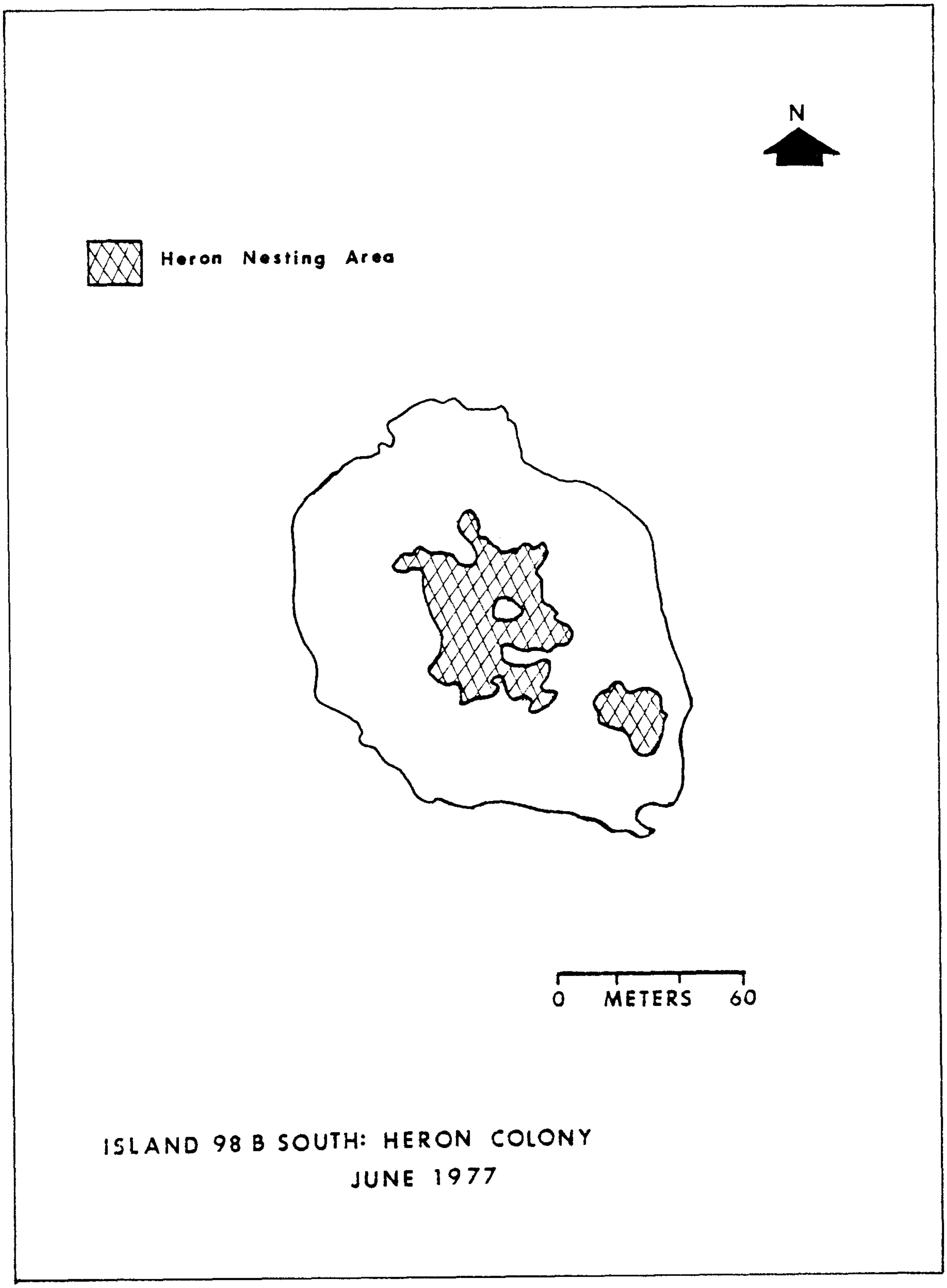

Figure 28. Map of heronry on Study Island 98B South

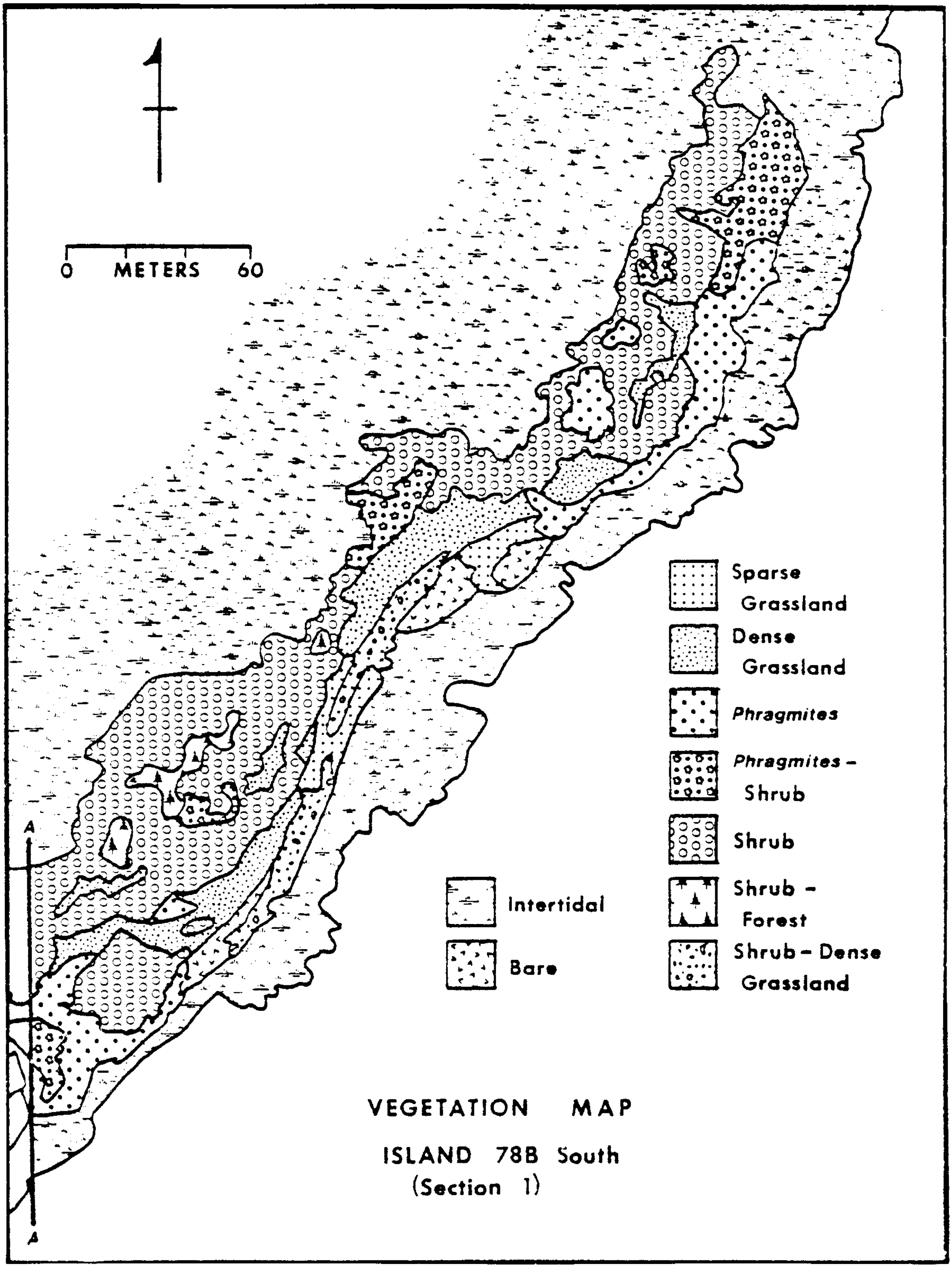

Figure 29a. Vegetation map of Study Island 78B South, section 1

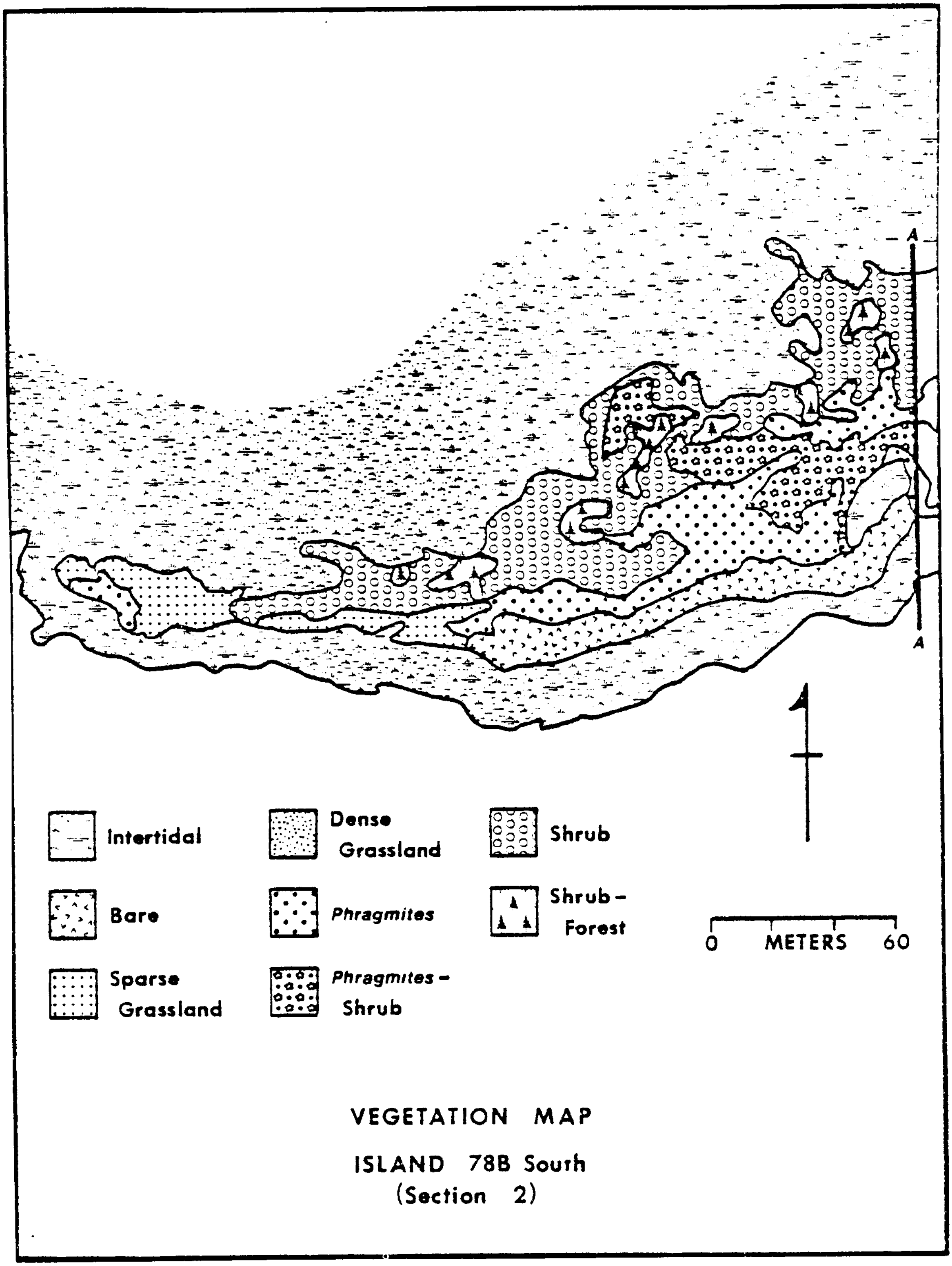

Figure 29b. Vegetation map of Study Island 78B South, section 2

It was dominated by pigweed, sea rocket, seaside goldenrod, poor-man's pepper, and Mexican tea (*Chenopodium ambrosioides*). Numerous other species, mostly herbs with a few grasses and shrubs, also occurred here. Seaward of the beach and drift area, peat or low marsh was found, depending upon location.

Study Island 103, Nummy Island

106. Island 103 (Nummy Island) is an irregular, rectangularly shaped salt marsh island with a road, numerous tidal creeks, channels, and tidal pools, plus four undiked and one diked dredged material deposit. Located at 39° 02' N and 74° 48' W in Cape May County, it abutts the northwest side of Hereford Inlet and is adjacent to the New Jersey Intracoastal Waterway. The entire island is approximately 129.3 ha and the diked dredged material deposit, selected for detailed study, is 1.2 ha in size. This site was last deposited upon in 1975. Tidal range on this site is 1.2 m and elevation of the dredged material study area ranges from 0.3 to 1.2 m. The island and deposit area are surrounded by salt marsh and shallow bay areas. Tidal flats, 0.31 ha, are adjacent to the study area. Vegetation on the dredged material deposit study area is characteristic of an early seral stage.

107. Several areas of salt pannes bordered the dike, especially on the south side furthest from open water. The dike was in a state of disrepair on that side and in some places only a remnant remained. Common reed was dominant on the dike, and seaside goldenrod, saltgrass,and orach were also present. Plants common to the high marsh or drift areas, sand-spurrey (*Spergularia marina*), sea-purslane (*Sesuvium maritimum*), smooth cordgrass (*Spartina alterniflora*),and sea rocket were also found on the dike area. Inside the dike, the area was mostly bare sand or dried dredged material sediments, with large shells throughout. Some debris was also in evidence. Species vegetating the dike were also found occasionally on the bare area. The center of the deposit was vegetated by 1.0 to 2.0-m high common reed with some orach growing on the dried mud. Reed was advancing from the center onto the bare area

(Figure 30).

108. Nummy Island supported colonies of laughing gulls (*Larus atricilla*) and common terns on its salt marsh areas and great black-backed gulls and herring gulls on dredged material areas. The diked dredged material deposit study area supported a colony of 150 pairs of herring gulls and eight pairs of great black-backed gulls. Their nests were distributed through the bare, reed and dike vegetation communities (Figure 31). Nests were placed upon bare sand mixed with clam shell and often on the dike at the base of herbaceous plants, though many were on bare areas with no vegetation, and one was in an outfall pipe through the dike. Nests on the other dredged material deposits were often on bare sand and shell though many were in saltmeadow cordgrass and at the base of low shrubs and herbaceous vegetation. Evidence of rat predation and habitation were also found on these portions of the island.

109. Nummy Island was a nesting area for herring gulls, great black-backed gulls, and laughing gulls in 1976 (Appendix A) as well as 1977. By 6 June 1977 there were herring gull and great black-backed gull chicks running around. However, many of the herring gull nests still had eggs in them, while the great black-backed gulls were more advanced with all of them having large chicks. The laughing gulls and common terns had nests with eggs, though some clutches were incomplete. The nearest herring gull-great black-backed gull colony to Island 103 was only 0.2 km away and was also on Nummy Island on an undiked dredged material deposit on the northeast side of the tidal channel, with salt marsh separating it from the study site.

Study Island 85C, Devils Thoro

110. Island 85C (Devils Thoro) is a diked dredged material island in Cape May County. It is located at 39° 14' N and 74° 39' W, adjacent to the New Jersey Intracoastal Waterway, about 1.8 km northwest of Corson Inlet's, and is just north of Island 85dmi. A salt marsh and approximately 1 km separate the study island from a beach

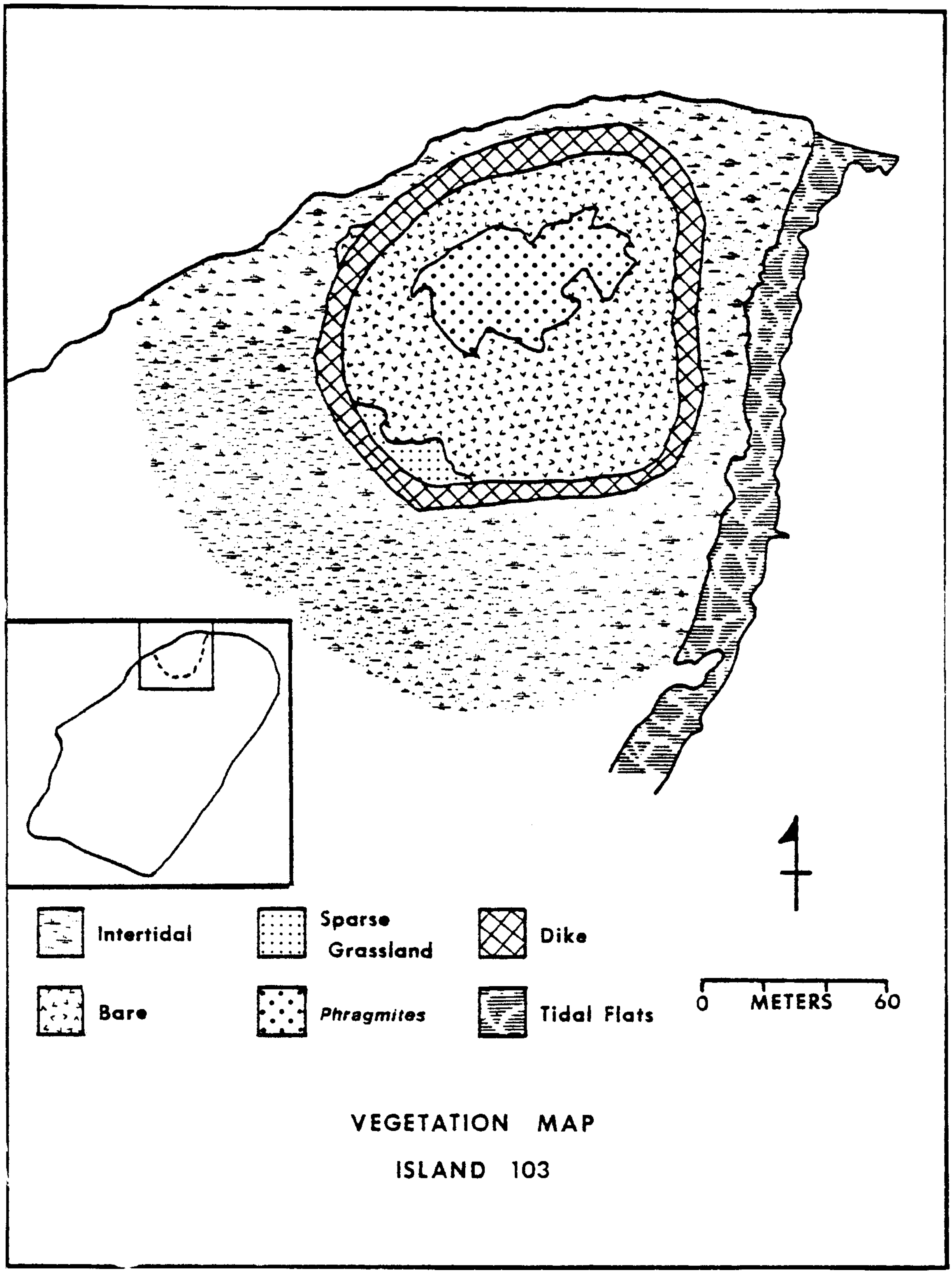

Figure 30. Vegetation map of Study Island 103

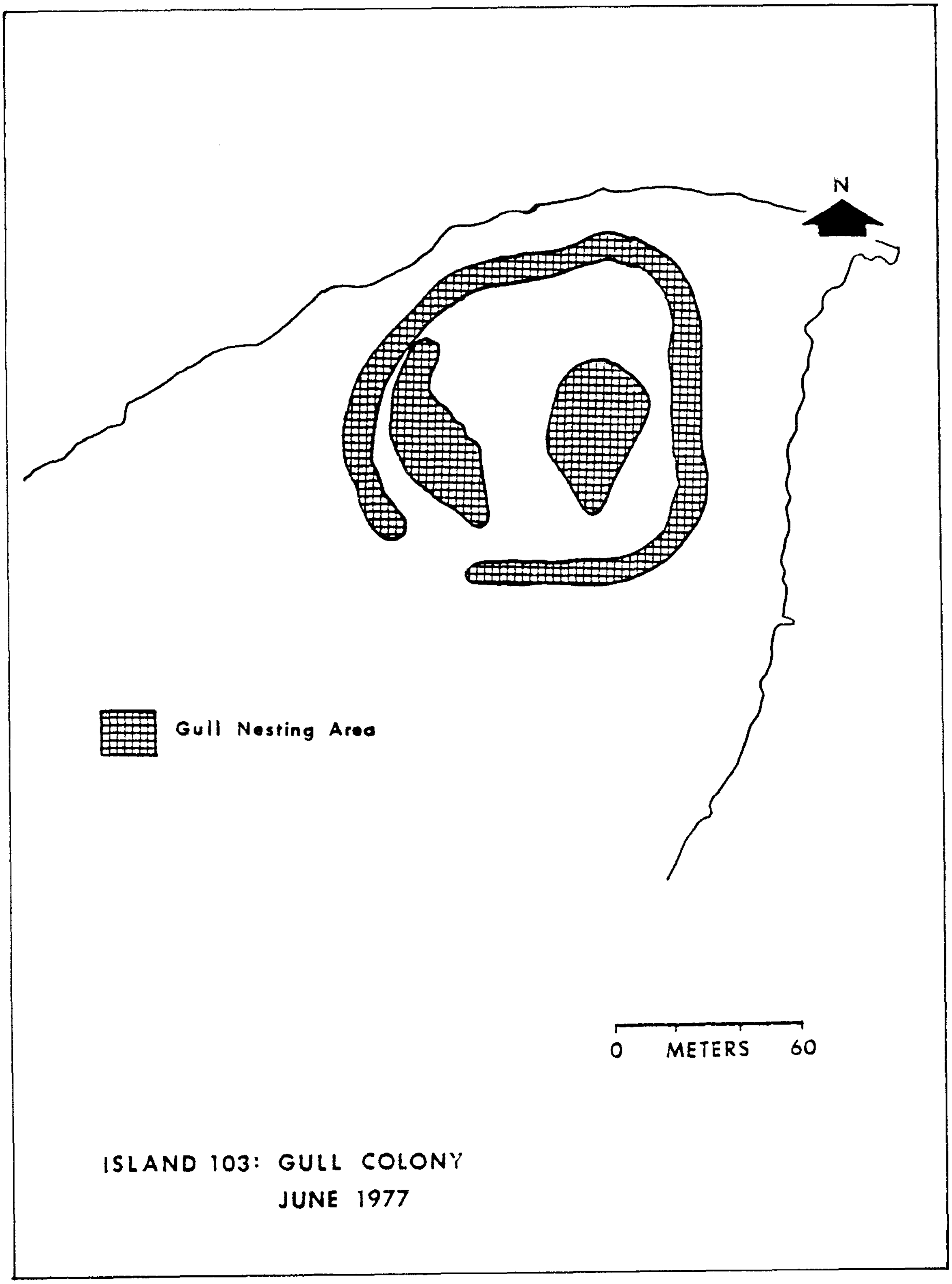

Figure 31. Map of gull colony on Study Island 103

development at the south end of Peck's Beach. The dredged material deposit is 4.0 ha in size and was last used for deposition in 1976. As with study Island 45A, the 1976 dredged material deposition appears to have covered only part of the original dredged material deposit. Tidal range in the area is 1.1 m, and 0.2 ha of tidal flats are adjacent to the dredged material deposit. The highest elevation on the site is the dike area at 1.5 m. Vegetation on the site is characteristic of an early seral stage but mid seral vegetation is also present (Figure 32).

111. The dike area was 1.0 m wide and supported a varied, mostly herbaceous, vegetation community. Common reed was dominant with pokeweed (*Phytolacca americana*), wild bean, and red fescue grass also common. Inside the dike was an essentially bare expanse of the most recent dredged sediments. The substrate here was sand, with blue mussel (*Mytilus edulus*) shell in some places. Open water was found on the southern end and dried mud lined the two adjoining deposit sides. Most of Island 85C was covered by a dense stand of common reed 1.8 to 3.0 m high. At the center of the reed-covered area was an open area of high elevation (possibly the apex of earlier deposits). This central portion had a variety of plant species and growth forms dominated by 1.0 to 2.0-m high reed. Bluestem, evening primrose (*Oenothera biennis*), yarrow, and red fescue grass composed the herb layer. Small fleabane and vulpia were found here also (they were also present on Study Islands A12 and 51B). They may have been relicts from an earlier successional stage of this deposit. Numerous shrubs were scattered throughout this open area. Species included were groundsel, bayberry, winged sumac, some red cedar, and some poison ivy. A few other places with similar vegetation were found irregularly scattered within the common reed.

112. On the northern end of the island was an area of live and dead reed which had been subjected to approximately 0.6 m of sand burial. Some dead groundsel shrubs, also buried by sand, were found here as well. The sand appeared to have been from wind transport.

Study Island 109, Shaw Island

113. Island 109 (Shaw Island) is an irregularly shaped, undiked

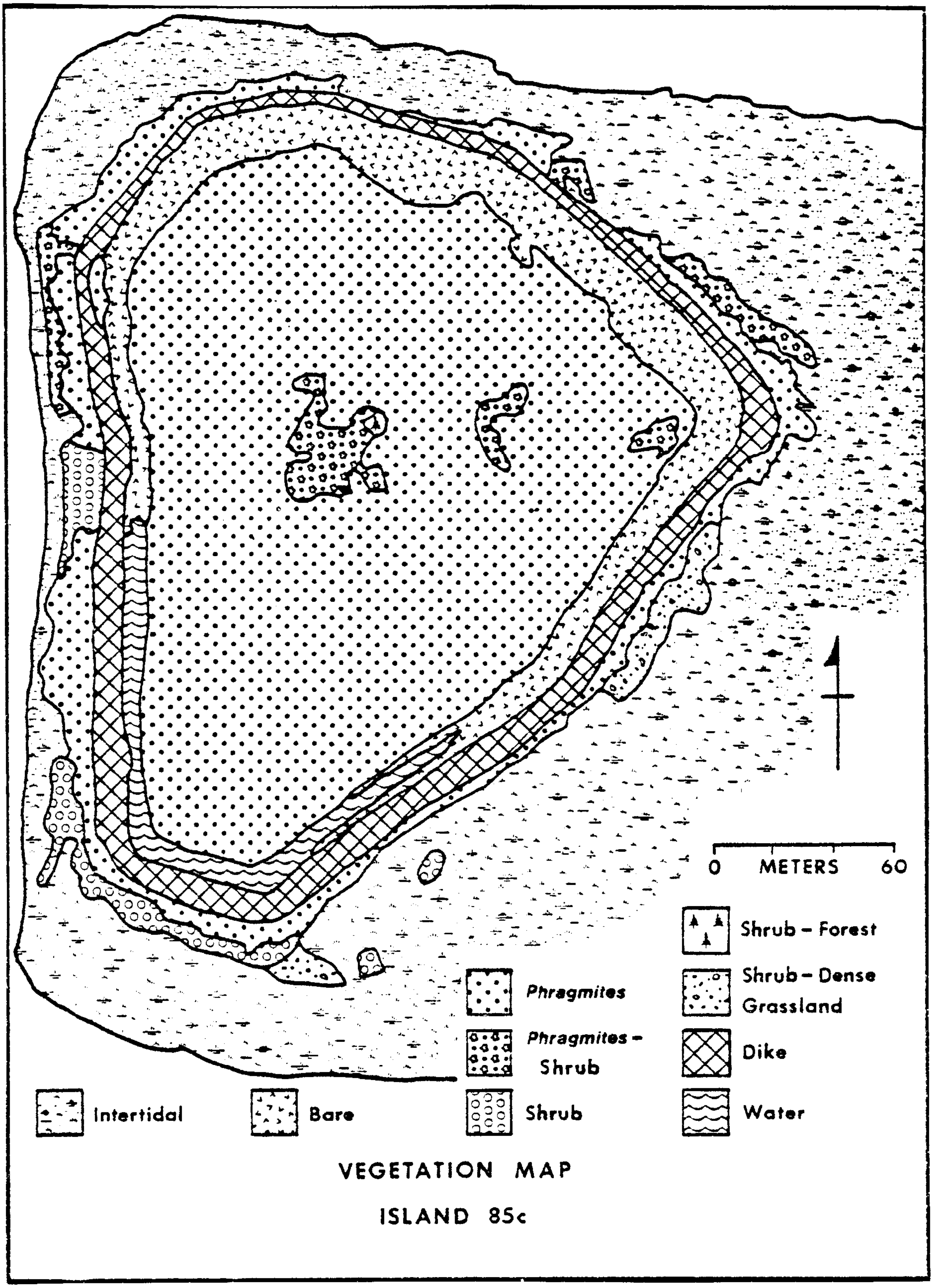

Figure 32. Vegetation map of Study Island 85C

dredged material island in Cape May County. Located at 39° 59' N and 74° 51' W, adjacent to the New Jersey Intracoastal Waterway, it lies about 5.6 km southwest of Hereford Inlet and is separated from Wildwood Crest by a narrow channel. Shaw Island is a large island, 32.7 ha in size, containing several dredged material deposits. Only one 2.1 ha portion was studied, an area exhibiting circular vegetative growth patterns on the southwest and which also contains a heronry. A sewage treatment facility is on the southeast side of the island. The eastern side of the island has a great deal of debris (lumber, bottles and cans) washed up on it. Dredged material was last deposited on Shaw Island in 1965. Tidal range on this island is 1.3 m and tidal flats (2.1 ha) are adjacent to the study area. Elevation is estimated at 1.5 m on the highest portions of the island. Vegetation on Shaw Island is characterized by mid seral stage species but early and late seral stage vegetation is also present (Figure 33).

114. The island was a complex mixture of common reed, bayberry, groundsel, winged sumac, red cedar, marsh elder, and high marsh and successional drift species. The salt marsh border of the southwestern deposit area was salt panne in some places and abundant drift material in others. On the west side of the deposit were areas of high marsh dominated by saltmeadow cordgrass with abundant marsh elder. On the northeast side was a stand of common reed. The east side had a shrub thicket with bayberry, groundsel, winged sumac, poison ivy, and Virginia creeper (*Parthenocissus quinquefolia*). Occasional red cedar and black cherry also occurred in the shrub thickets. Large areas included mixtures of 3.0-m high reed and shrubs.

115. Shaw Island had a small heronry (Figure 34) of yellow-crowned night herons with a few glossy ibises whose nests were located in reed-shrub, shrub and shrub-forest vegetation communities. The yellow-crowned night heron nests were found both high and low in tall shrubs of bayberry, black cherry, and red cedar trees. Glossy ibis nests were lower and well hidden by reed. Shaw Island did not have a heronry upon it in 1976 as far as is known (Appendix A), but it has been used as a

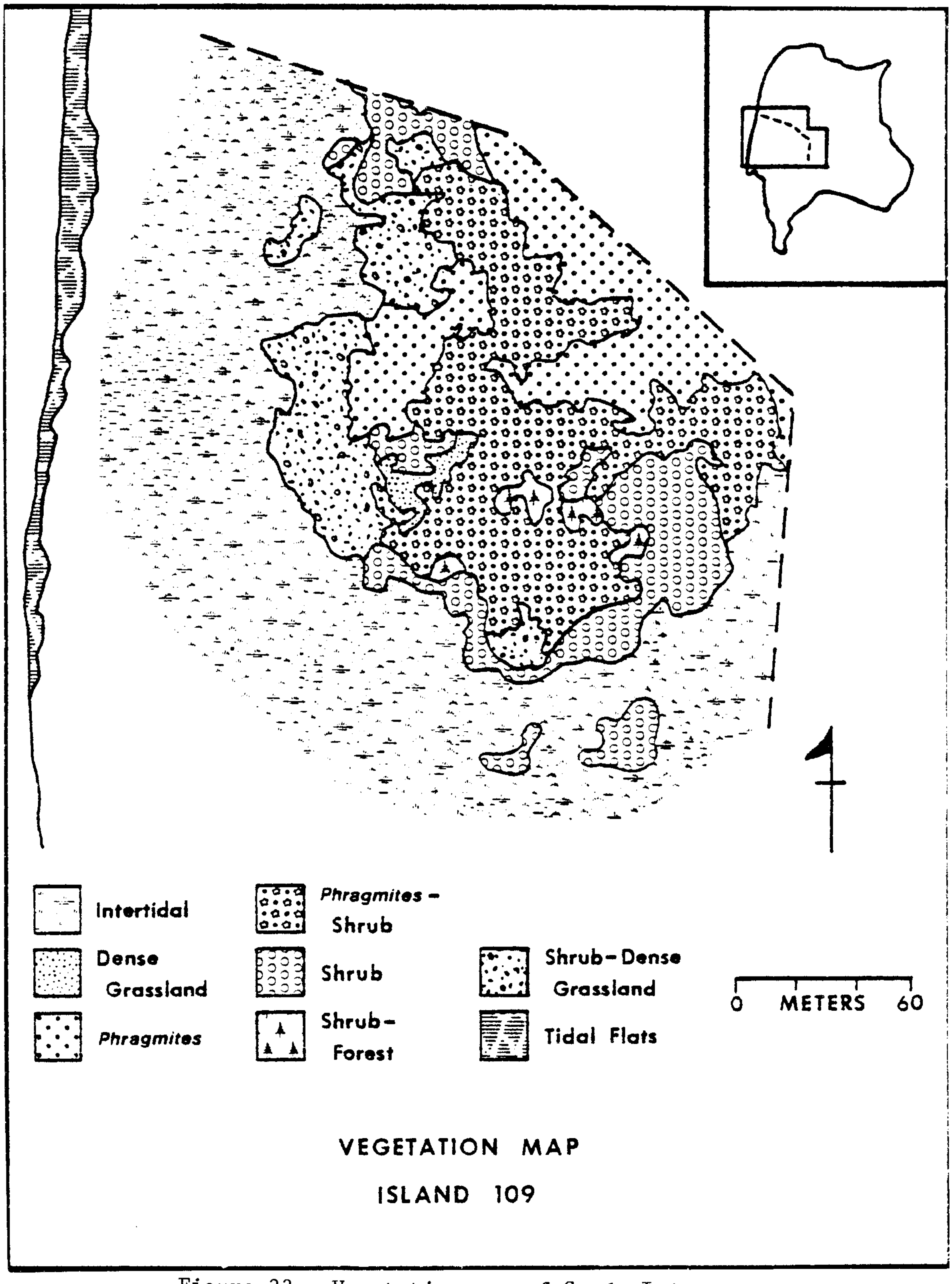

Figure 33. Vegetation map of Study Island 109

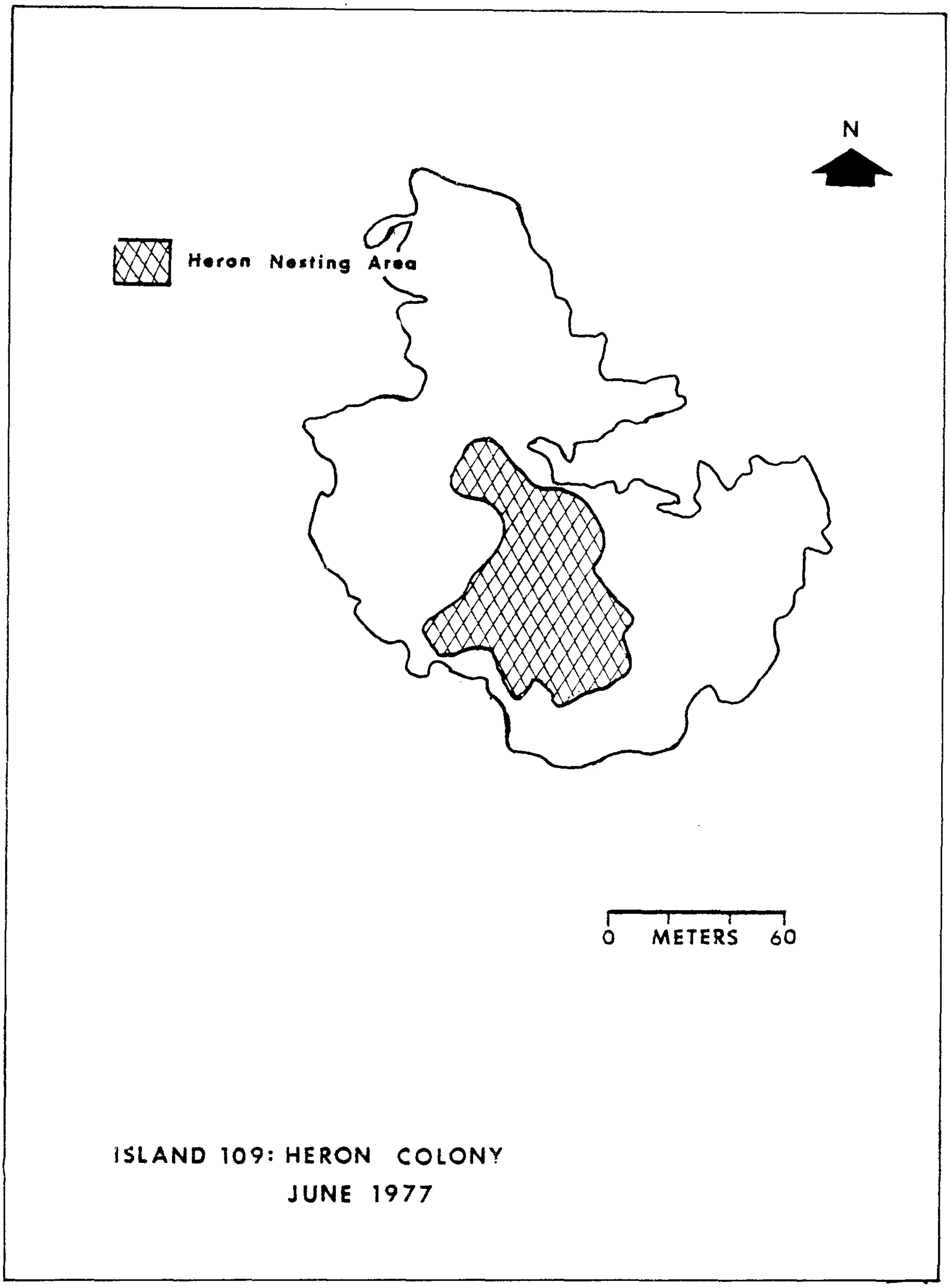

Figure 34. Map of heronry on Study Island 109

heron nesting colony site in the past (personal communication, May 1977, J. Lomax, Cape May Bird Observatory, Cape May, NJ). The nearest heronry with the same species as Shaw Island was 0.2 km across the Intracoastal Waterway Channel at Stingaree Point (colony 67, Figure C2). In 1976 Stingaree Point supported one of the largest heronries in New Jersey but a fox, observed on the May 1977 survey, seemed to have decimated this colony by June, when its numbers were badly depleted compared to the 1976 nesting season (Appendix A).

Study Island 109 South

116. Island 109 South is a circular, undiked dredged material island in Cape May County. It is adjacent to the New Jersey Intracoastal Waterway, located at 38° 59' N and 74° 51' W, about 3 km north of Cape May Inlet, and 6.4 km south of Hereford Inlet. The dredged material deposit is on a salt marsh opposite Wildwood Crest. It is almost 2 ha in size and the last dredged material deposition date for this site is unknown. However, dredged material deposition at unspecified sites in this area occurred in 1965. Tidal range in this area is 1.3 m and tidal flats (0.1 ha) are adjacent to the dredged material deposit. Elevation on the island is estimated at 1.0 m at the dome. Island 109 South has a small sand beach subject to heavy recreational use from passing boaters. Vegetation on Island 109 South is characteristic of an early seral stage but mid and late seral stage vegetation is also present (Figure 35).

117. The deposit area was vegetated on the south side by common reed, about 2.1 m high. In some areas winged sumac, groundsel, bayberry, and elderberry were codominant with reed. A few 3.0-m high black cherry and 3.6-m high red cedar were also found here. The northern part of this upland was characterized by Japanese honeysuckle (*Lonicera japonica*), which seemed to be draped over all vegetation. Dense grasslands of panic grass (*Panicum lanuginosum*), bluestem, broom sedge (*Andropogon virginicus*),and yarrow were found on the northeast side of this area. However, these grasslands had been invaded by shrubs

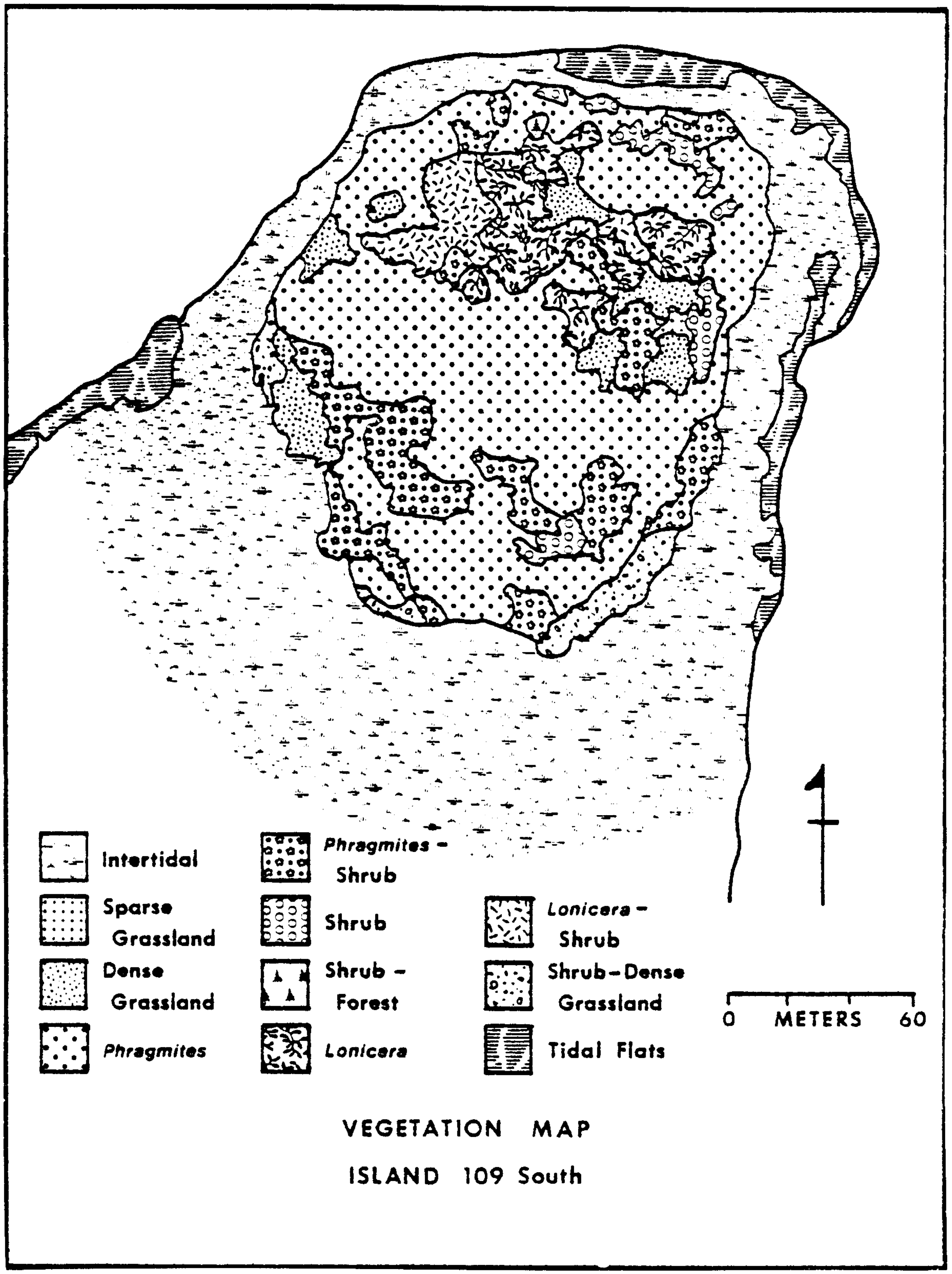

Figure 35. Vegetation map of Study Island 109 South

(winged sumac, groundsel, bayberry, elderberry, common reed) and vines. The viniferous vegetation included honeysuckle, Virginia creeper, and poison ivy. The honeysuckle grew not only in the grassland, but also climbed over dead reed stems and skeletons of groundsel and was, in large part, impenetrable. Island 109 South was the only study island which had honeysuckle as a dominant plant species and in such abundance. It even seemed to be displacing common reed. Specimens of white mulberry (*Morus alba*) and sassafras (*Sassafras albidum*) were also noted, and elderberry was quite common.

Vegetation Studies

118. Table 3 lists major plant species collected on the 21 dredged material study sites. This is not a complete listing of all species found in the study area, but is based upon field observations and on sampling of 1085 quadrats and 28 transects on the dredged material study islands. Species present were indicative of low tidal marsh, high tidal marsh, grassland, shrub-thicket, and dune-woodland communities.

Succession

119. Vegetational and successional patterns on study islands conformed well to those described by Martin (1959), Daiber (1974), Chapman (1960), Ranwell (1972) and Robichaud and Buell (1973) for the tidal salt marshes and dunes of the outer coastal plain of southern New Jersey. Analysis of successional trends on the study islands was based upon a relatively small sample of the 21 sites, investigated during only one field season. Records pertaining to the deposition of dredged material on specific sites along the New Jersey Intracoastal Waterway were incomplete or non-existent, making correlation of present vegetation patterns with island age difficult.

120. Reasonably reliable age records exist for only 13 of the 21 islands, so discussion of successional trends is based mostly upon them. Other islands are discussed only if successional

Table 3

Plant Species Found on New Jersey Dredged Material Study Islands 1977

Scientific Name	Common Name
**Acer rubrum*	Red maple
Achillea millefolium	Yarrow
Amaranthus retroflexus	Pigweed; green amaranth
Ambrosia artemisiifolia	Common ragweed
Amelanchier canadensis	Serviceberry; shadbush
Ammophila breviligulata	American beachgrass
Andropogon scoparius	Bluestem
Andropogon virginicus	Broom sedge
Apocynum cannabinum	Indian hemp
Arenaria peploides	Sea purslane; seabeach sandwort
**Asclepias syriaca*	Common milkweed
Atriplex patula	Orach
Baccharis helimifolia	Sea myrtle; groundsel
Bassia hirsuta	-----
Bromus tectorum	Brome grass
Cakile endentula	Sea rocket
Carex albolutescens	Sedge
Chenopodium album	Pigweed; lamb's quarters
Chenopodium ambrosioides	Mexican tea
Cirsium arvense	Canada thistle
Cirsium vulgare	Bull thistle; common thistle
Convolvulus sepium	Wild morning glory; hedge bindweed
Cyperus sp.	------
Cyperus esculentus	Yellow nutgrass
Cyperus odoratus	Nutsedge
Digitaria sanguinalis	Crab grass; finger grass

(Continued)

* No specimen collected

Table 3 (Continued)

Scientific Name	Common Name
Distichlis spicata	Salt grass alkali-grass
Eragrostis spectabilis	Tumble grass; petticoat climber
Erigeron canadensis	Fleabane
Erigeron pusillus	Small fleabane
Eupatorium album	White thoroughwort
Eupatorium hyssopifolium	Thoroughwort
Festuca rubra	Red fescue grass
Gnaphalium obtusifolium	Catfoot
Hemerocallis fulva	Daylily
Heterotheca subaxillaris	Camphorweed
Hibiscus palustris	Swamp rose mallow
Hudsonia tomentosa	Beach heather; poverty grass
Iva frutescens	Marsh elder
Juncus dudleyi	Rush
Juncus gerardi	Black grass
Juniperus virginiana	Red cedar
Lactuca biennis or floridana	Wild lettuce
Lactuca canadensis	Wild lettuce
Lactuca scariola	Prickly lettuce
Lathyrus japonicus	Beach pea
Lechea maritima	Maritime pinweed
Lepidium virginicum	Poor-man's pepper
Limonium nashii	Sea lavender
Linaria canadensis	Toadflax
Lonicera japonica	Japanese honeysuckle

(Continued)

Table 3 (Continued)

Scientific Name	Common Name
Mollugo verticillata	Carpetweed
Morus alba	White mulberry
Myrica pennsylvanica	Bayberry
Oenothera biennis	Evening primrose
Oenothera fruticosa	Evening primrose
Oenothera parviflora	Evening primrose
Opuntia humifusa	Prickly pear cactus
Panicum dichotomiflorum	Panic grass
Panicum lanuginosum	Panic grass
Panicum virgatum	Switchgrass
Parthenocissus quinequefolia	Virginia creeper
Phragmites communis	Common reed
Pinus nigra	Austrian pine
Phytolacca americana	Pokeweed
Pluchea purpurascens	Marsh fleabane
Poa annua	Bluegrass
Polygonella articulata	Jointweed
Polygonum aviculare	Knotweed
Polygonum hydropiper	Common smartweed
Polygonum punctatum	Water smartweed
Polygonum ramosissimum	Bush knotweed
Prunus serotina	Black cherry
Rhus copallina	Dwarf sumac; winged sumac
**Rhus radicans*	Poison ivy
Rosa virginiana	Rose
Rubus bifrons	Blackberry
Rumex acetosella	Sheep sorrel; common sorrel

(Continued)

Table 3 (Concluded)

Scientific Name	Common Name
Rumex crispus	Yellow dock
Salicornia bigelovii	Dwarf saltwort
Salicornia europaea	Samphire; chickenclaws
Salicornia virginica	Perennial saltwort
Salix alba	White willow
Salix nigra	Black willow
Salsola kali	Common saltwort
Sambucus canadensis	Elderberry
**Sassafras albidum*	Sassafras
Scirpus americanus	Three-square; chair-maker's rush
Sesuvium maritimum	Sea purslane
Solanum americanum	Nightshade
Solanum dulcamara	Nightshade; bittersweet
Solidago altissima	Goldenrod
Solidago sempervirens	Seaside goldenrod
Solidago tenuifolia	Goldenrod
Spartina alterniflora	Smooth cordgrass
Spartina patens	Saltmeadow cordgrass
Spergularia marina	Sand spurrey
Strophostyles helvola	Wild bean
Suaeda lineraris	Sea blite
Teucrium canadense	American germander; wood sage
Trifolium arvense	Rabbitfoot clover
Triplasis purpurea	Sand grape
Vitis aestivalis	Summer grape
Vulpia octoflora	Vulpia
* *Xanthium strumarium*	Cocklebur; coltbur

relationships could be easily discerned. The islands selected for analysis were utilized as disposal sites from 1963 through 1969, with a six year gap before use again in 1975. Accurate determination of the ages of older plant associations was not possible. Because of this, it was difficult to determine the exact time period over which the present plant communities have reached their current succession status.

121. Age and extent of the dredged material island depositions are not the only factors influencing plant succession. Martin (1959) found that microtopography, groundwater availability, depth of sediment deposition, salt spray tolerance, and water and soil salinity were all important factors in the determination of vegetation patterns at nearby Island Beach, New Jersey. Frequency of, and susceptibility to, storm inundation (especially in areas with little or no elevation), the presence or absence of diking, seed availability, and seed transport mechanisms are also factors that should be considered when studying plant succession. The following discussions are of various stages found on study islands:

a. Early seral stages

(1) The plant communities classified as representing an early stage on dredged material islands in New Jersey varied with the deposition patterns on the islands studied: diked, domed, or spread in a low profile. Because of these configurational differences, their early successional stages also differed.

(2) On diked study islands, sediments deposited behind the dike were essentially unvegetated for at least two years. The dike probably restricted the introduction of colonizing seeds and rhizomes carried by tides and storms under natural conditions. Some of the first plants found on early seral stage diked study islands were saltgrass, sand spurrey, sea blite (*Suaeda maritima*), sea purslane, common reed, pigweed, orach, and blue grass (*Poa annua*). Salt-tolerant species are slower to colonize these diked dredged material areas because of the higher salinity of the sediments after the saltwater portion of the dredged material evaporates. Ponding from rainwater and/or flood waters that periodically cover parts of the rim-like depositions and are retained within the dike,

would also retard colonization by pioneer species intolerant of standing water.

(3) Diked study islands 45A, 85C, and 103 were in early stages of succession. The dikes surrounding the deposits were in more advanced stages of colonization and succession than the areas internally adjacent to them. High, central portions were also more vegetated than lower areas surrounding them. Common reed seemed to be the predominant species, colonizing almost all areas on such islands.

(4) Several of the study islands (A12, A12 North, 51B) were dome shaped. They ranged in elevation from less than 1.0 m to 3.0 m above the salt marsh surface. Definite ages for most of them are lacking. The bare sand, shell, and/or pebbled areas on the dome top were often invaded by sedges (*Cyperus* sp.), vulpia, sand grape (*Triplasis purpurea*), brome grass, small fleabane, and evening primrose (*Oenothera parviflora*). These species (or combinations of them) formed a sparse grassland community at the highest elevations on several of the domed islands studied and represented an early seral stage on deposits that were at least 12 years old in some instances.

(5) At the base of the dome, dense grassland was typically found; it was most often composed of American beachgrass and seaside goldenrod. The lower areas were colonized by common reed. Data indicate that over a period of time the dense grassland species cover the dome, followed by common reed.

(6) Many of the same sparse grassland species on early seral stage domes were also present in less abundance on 11 to 14 year old summits in mid seral stages. These had mostly dense grassland species with some shrub invasion. Vegetation maps suggest that domed deposits take longer to advance beyond an early seral stage of sparse grassland than do islands with less elevated dredged material.

(7) Most of the islands studied had a low profile. No study islands were in early seral stages, but common reed was probably a major pioneer species. Reed advances by rapid rhizome growth and forms tall, dense stands. It is one of the earliest and most persistent of all species invading these deposits. For example, Island 108B (12 years old) was dominated by common reed which occurred in a single dense stand although some mid seral growth had begun. Periodic inundation of low-lying deposits by storm and high tides seems to maintain early

seral stages by drowning or salting out the less tolerant woody species characteristic of later seral stages.

(8) On older low profile dredged material islands, dense grasslands were found. The dense grasses may have been initial invaders or may have been followed by earlier sparse grassland species. On some low profile islands, drift (cordgrass and reed stems) covered large portions. These islands had characteristic succession patterns which varied somewhat from islands previously described. For example, Island A35 is in an area where the natural vegetation community is tidal salt marsh, and most of its surface was covered by drift. The drift was invaded by sea rocket and orach. The island periphery had smooth cordgrass, *Bassia hirsuta*, and common saltwort (*Salsola kali*) growing in abundance. Interior portions had an open, herbaceous cover dominated by goldenrod, seaside goldenrod, and poor-man's pepper. Vines growing were wild bean and wild morning glory.

(9) Islands did not differ in mid and late seral stage vegetation to the same extent that they differed in early seral stages. Characterizations of later seral stages apply to the study islands regardless of their configeration.

b. Mid seral stages

(1) Mid seral stages on Study Islands A59a, 98A, and 98B North were characterized by shrub invasion of sparse grassland, dense grassland, or pure reed stands. The oldest deposit which had mid seral vegetation was nine years old, and the stage probably begins at an earlier age. Shrubs usually found in this stage are bayberry, groundsel, and marsh elder. Winged sumac was common on some islands and elderberry occurred occasionally.

(2) At the central portion of some islands with dense grassland, the mid seral stage was initiated by both reed and shrubs. This situation occurred on islands with subdomes of lower elevation than the main dome (Islands 45A and 85C).

(3) Islands with much drift vegetation were characterized at mid seral stages by reed, bayberry, and/or poison ivy growing through open herbaceous vegetation. Where upland areas bordered salt marsh, marsh elder (with or without reed) grew through mats of drift material. Marsh elder was scattered and/or mixed with reed throughout the upper salt marshes. On Islands 85dmi and A59a elder-high marsh mixtures may have been invaded by common reed.

(4) On most islands the reed-shrub mixture covered a large area. In time, the shrubs mixed with the reed will probably exceed the height of the reed and dominate the association. However, shrub domination was observed where the shrub thickets had probably become established before invasion by reed.

(5) In some areas, especially in early reed-shrub associations, numerous shrub skeletons were found. Islands 45A and A61c contained a larger number of these skeletons than most other islands. A late frost in May 1977 was probably responsible for this. Saltwater flooding during storms or dredged material deposition on pre-existing shrub associations produces similar effects.

(6) Grasslands were only a minor component of the mid seral stage islands, but the grassland communities were probably important to the earlier development of the shrub thicket communities. In dense grassland succession, the grasses and herbs common in the earlier seral stages persisted in the ground layer. With increasing density of the reed-shrub canopy, the grasslands will probably disappear.

c. Late seral stages

(1) Shrub thickets were considered a late seral stage on the study islands. Shrubs establish on dredged material deposits either alone or mixed with common reed. Shrubs dominating the reed-shrub associations increase in cover and density to form thickets. Islands 9 through 14 years old (A61c, 98B North, 109) showed this, but the ages of the deposition from which the shrubs grew were undetermined.

(2) Most of the same species occurring in mid-seral stage uplands dominated the later seral stages of bayberry, groundsel, and winged sumac. Marsh elder, sometimes mixed with groundsel and bayberry, formed thickets on the deposit perimeter.

(3) The shrub-forest was the most advanced seral stage observed on study islands. The most important tree species were red cedar and black cherry. The trees appeared to be randomly spaced through the shrub thickets and were occasionally found in mid seral stage shrub-grassland communities. Shrub-forest was found on 12 to 14 year old islands (109, 98B South). Poison ivy and Virginia creeper were common within the shrub-forest community.

(4) Data are available on the age, characteristic seral stage, other stages present, and vegetation communities present on each study island (Table 4). No plant species or vegetation communities were found at the study sites that were atypical of the salt marshes and sand dune habitats of southern New Jersey. Additional discussion of the vegetation found on all study islands and its relation to colonial nesting birds is presented in the following sections.

Bird Studies

122. Table 5 lists colonial nesting seabird and wading bird species that occur in New Jersey. Only great blue herons (*Ardea herodias*) and roseate terns (*Sterna dougallii*) were not found nesting in the study area in June 1977, and green herons were not common. Least terns, common terns, gull-billed terns (*Gelochelidon nilotica*), and Forster's terns were nesting in the study area, as were black skimmers ( ), great black-backed gulls, laughing gulls, and herring gulls. Little blue herons (*Florida caerulea*), great egrets (*Casmerodius albus*), snowy egrets, Louisiana herons (*Hydranassa tricolor*), black-crowned night herons, yellow-crowned night herons, and glossy ibises comprised the wading bird species studied. Appendix A provides a detailed account of the history and breeding phenology of these species in New Jersey. Herring gulls, great black-backed gulls, laughing gulls, Forster's terns, and all of the above wading bird species were in colonies and nesting by the second week of May 1977. Common terns were arriving at colonies from early May and were already on nest sites by 8 May in northernmost sites. Black skimmers, least terns, and laughing gulls were returning to New Jersey in May. By the first week of June, all species had nests, eggs, and/or young, though many of the black skimmers were not yet nesting, and many of the gulls were renesting after high storm tides had washed away their nests. Many of the herons had young, though many other nests had only eggs or newly hatched young. The wading bird species had started arriving on their breeding territories in New Jersey as early as March; in June some were renesting because certain colony sites had just been burned (Pork Island) or

Table 4

Deposit Age and Seral Stage Relationships

Island	Last Deposit[+]	Dominant Plant Communities	Characteristic Seral Stage	Other Seral Stages Present
A12	pre 1969*	GS-P-PS	early	mid
A35	pre 1969*	P-GD-PS-S	early	mid; late
45A	1976	B-P-GD(S)	early	none
X27	pre 1969*	GS-S-P-PS	late	early; mid
A61c	pre 1959**	P-S-PS	early	mid; late
85dmi	1966	P-S-PS	late	early; mid
98A	1968	PS-SGD	mid	early; late
98B North	1968	P-S-PS	mid	early; late
98B South	1968	P-PS-SF	late	early; mid
103	1975	B-P	early	none
109	1965	P-S-PS-SF	mid	early; late
A12 North	pre 1969*	B-P-PS	early	mid; late
A43a	pre 1969	P-PS	early	mid

(Continued)

+ by U.S. Army Engineer District, Philadelphia.

* Fred Lesser, Ocean County Mosquito Control Commission

** Based upon bird banding data, U.S. Fish and Wildlife Service, Patuxent, MD.

P = reed; S = shrub; PS = reed-shrub; SF = shrub-forest; GS = sparse grassland; GD = dense grassland; GD(S) = dense grassland with shrubs; B = bare; SGD = shrub-dense grassland; L = honeysuckle; LS = honeysuckle-shrub.

Table 4 (Concluded)

Island	Last Deposit+	Dominant Plant Communities	Characteristic Seral Stage	Other Seral Stages Present
45B	1963	P-PS	early	mid; late
51B	1965	P-PS-GS-GD	early	mid
A59a	1968	P-PS-GS-SGD	mid	early; late
78B South	1969	PS-S-SF	late	early; mid
85c	1976	B-P-GD(S)	early	mid; late
85 South	1966	S-PS-SGD	late	mid
108B	1965	P-PS	early	mid
109 South	1965?	P-PS-L-LS	early	mid; late

Table 5

List of Colonial Nesting Seabirds and Wading Birds in New Jersey

Scientific Name	Common Name
Ardea herodias	Great blue heron
Butorides virescens	Green heron
Florida caerulea	Little blue heron
Bubulcus ibis	Cattle egret
Casmerodius albus	Great egret
Egretta thula	Snowy egret
Hydranassa tricolor	Louisiana heron
Nycticorax nycticorax	Black-crowned night heron
Nyctanassa Violacea	Yellow-crowned night heron
Plegadis falcinellus	Glossy ibis
Larus marinus	Great black-backed gull
Larus argentatus	Herring gull
Larus atricilla	Laughing gull
Gelochelidon nilotica	Gull-billed tern
Sterna forsteri	Forster's tern
Sterna hirundo	Common tern
Sterna dougalli	Roseate tern
Sterna albifrons	Least tern
Rynchops niger	Black skimmer

disturbed by predators (Stingaree Point). By late August, all species had fledged young.

123. The survey and census figures presented in the following pages are based upon June 1977 census and survey data. These are minimal figures since birds away from their nests at the time of the census were not counted. Figures for the Stone Harbor Heronry are probably much lower than the actual breeding population of this major site. Counts were difficult because of the protected nature of the site, its large size, and impenetrable vegetation. Ground truthing and additional census/survey data from others in the area (Kane and Farrar 1977; Burger and Lesser 1976; personal communication, January 1978, Joan Galli, Division of Fish, Game and Shellfisheries, Trenton, NJ) indicate that the census figures are within reasonable estimates of the breeding populations of these species in the study area.

Survey of colony sites

124. A total of 117 colony locations were found during the June 1977 survey from Cape May Inlet to Manasquan Inlet. Common terns nested at 52 sites and were the most widespread species. Herring gulls occurred at 40 sites and were also widespread, often with common terns and herons. Great black-backed gulls occurred at 21 sites, always in small numbers and usually with herring gulls. Laughing gulls were found nesting at 31 sites, mostly in salt marshes, and did not nest north of Barnegat Inlet. Least terns occurred at 15 sites early in June and black skimmers were found at 14 sites, though they did not breed at all of them. Gull-billed terns were found breeding at three locations and Forster's terns at six. Heronries were located at 32 sites and were of mixed species composition. Figure 36 indicates the percentage of the total number of sites with each wading bird species. Black-crowned night herons, snowy egrets and glossy ibises were most widely distributed, and cattle egrets were least widely distributed (6 of 32 sites). No heronries were located north of Barnegat Inlet. Table 6 records the locations, names, and species composition at each site where a nesting colony was found. The site numbers refer to the

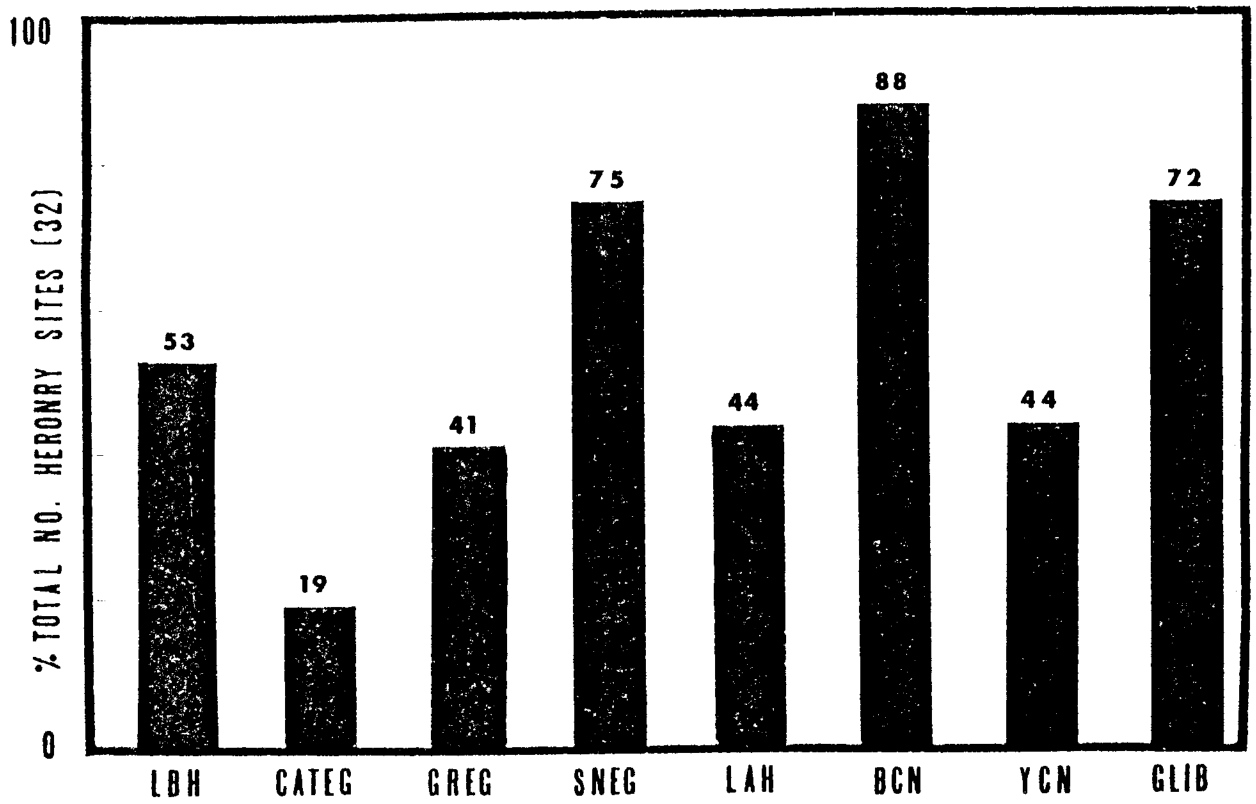

Figure 36. Wading bird species distribution on colony sites, showing percentages of heron sites by species. LBH= little blue heron; CATEG= cattle egret; GREG= great egret; SNEG= snowy egret; LAH= Louisiana heron; BCN= black-crowned night heron; YCN= yellow-crowned night heron; GLIB= glossy ibis

Table 6

1977 Coastal Nest Sites

Site No.	County	Name	Latitude	Longitude	Species Present
41	Atlantic	Absecon Inlet North	$39^{\circ}23'$	$74^{\circ}24'$	LT
45a*	Atlantic	Alex Island East & West	$39^{\circ}22'$	$74^{\circ}31'$	LG,CT
48	Atlantic	Bass Harbor	$39^{\circ}17'$	$74^{\circ}35'$	LT
46	Atlantic	Beach Thorofare	$39^{\circ}20'$	$74^{\circ}31'$	LG, CT
36a	Atlantic	Betsey Channel	$39^{\circ}26'$	$74^{\circ}22'$	HG, LG, FT, CT
60 dmi	Atlantic	Black Point	$39^{\circ}26'$	$74^{\circ}24'$	BCNH
38*	Atlantic	Bonita Tideway	$39^{\circ}24'$	$74^{\circ}24'$	LG, CT
78A dmi	Atlantic	Broad Thorofare	$39^{\circ}19'$	$74^{\circ}34'$	BCNH
35	Atlantic	Elder Island	$39^{\circ}27'$	$74^{\circ}20'$	GBBG, HG, CT
42a*	Atlantic	Flat Thoro	$39^{\circ}25'$	$74^{\circ}25'$	CT
38*	Atlantic	Golden Hammock Thoro Marsh	$39^{\circ}23'$	$74^{\circ}24'$	CT
33	Atlantic	Great Thoro	$39^{\circ}29'$	$74^{\circ}21'$	LG

(Continued)

* = new site location; dmi = dredged material island;

GNH = green heron; LBH = little blue heron; CATEG = cattle egret; GREG = great egret; SNEG = snowy egret

LAH = Louisiana heron; BCNH = black-crowned night heron; YCNH = yellow-crowned night heron; GLIB = glossy ibis;

GBBG = great black-backed gull; HG = herring gull; LG = laughing gull; GBT = gull-billed tern; FT = Forster's tern;

CT = common tern; LT = least tern; BLSK = black skimmer

Table 6 (Continued)

Site No.	County	Name	Latitude	Longitude	Species Present
34	Atlantic	Hammock Cove Island	39°27'	74°24'	SNEG, BCNH, GBBG, HG
47	Atlantic	Hospitality Creek	39°18'	74°34'	GBBG, HG, LG, CT, BLSK
A61b dmi	Atlantic	Islajo	39°25'	74°25'	LBH, CATEG, GREG, SNEG, LAH, BCNH, YCNH, GLIB, HG
36	Atlantic	Little Bay	39°26'	74°23'	GBT, CT
29	Atlantic	Little Beach Island	39°30'	74°20'	HG, CT, BLSK
31	Atlantic	Little Beach Island	39°30'	74°20'	BCNH, YCNH
31	Atlantic	Little Beach Island	39°30'	74°20'	LBH, SNEG, BCNH, YCNH, GLIB
A61c dmi	Atlantic	Little Heron Island	39°24'	74°26'	LBH, CATEG, GREG, SNEG, LAH, BCNH, GLIB, GBBG, HG
35	Atlantic	Little Mud Thoro	39°27'	74°21'	CT
39	Atlantic	Little Panama (Brigantine Blvd.)	39°23'	74°24'	BCNH, YCNH, GLIB
47a	Atlantic	Longport Sod Banks	39°19'	74°33'	LT
61 dmi	Atlantic	Oyster Thoro Marsh	39°26'	74°24'	GBBG, HG, LG, GBT, CT, BLSK
A59a dmi	Atlantic	Perch Cove Point (Big Shad Island)	39°28'	74°24'	BCNH, YCNH
40	Atlantic	Peter Beach	39°23'	74°24'	LT
46	Atlantic	Pork Island	39°20'	74°32'	YCNH (GREG, SNEG, BCNH, YCNH, GLIB nests burned out)
32	Atlantic	Pullen Island (Little Beach South)	39°28'	74°20'	GNH, CATEG, GREG, SNEG, BCNH GLIB
77 dmi	Atlantic	Risley Channel	39°20'	74°33'	GBBG, HG, LG, CT
30*	Atlantic	Seven Island (Newman Thoro)	39°31'	74°20'	GREG, SNEG, LAH, BCNH, GLIB

(Continued)

Table 6 (Continued)

Site No.	County	Name	Latitude	Longitude	Species Present
34a*	Atlantic	Simkins Thoro	39°28'	74°22'	LG, FT
42	Atlantic	Stake Thoro	39°23'	74°25'	GBBG, HG
37	Atlantic	Somers Bay	39°26'	74°23'	LG,CT
44a*	Atlantic	Ventnor City	39°21'	74°30'	LBH, SNEG, BCNH, YCNH, GLIB
44	Atlantic	Ventnor City Beach	39°21'	74°30'	LT
38a*	Atlantic	Wading Thoro	39°25'	74°26'	LBH, GREG, SNEG, LAH, BCNH, GLIB, GBBG, HG
45	Atlantic	Whirlpool Island	39°21'	74°31'	HG, LG, GBT, CT
58a*	Cape May	Avalon	39°06'	74°44'	GREG, SNEG, BCNH
53	Cape May	Burroughs Hole	39°11'	74°41'	LG,FT
71	Cape May	Cape May Inlet	39°57'	74°52'	SNEG, BCNH, YCNH, GLIB
58	Cape May	Cornell Harbor East	39°07'	74°43'	GREG, SNEG, BCNH, YCNH, GLIB
58	Cape May	Cornell Harbor West	39°07'	74°43'	LBH, SNEG, BCNH, YCNH
50	Cape May	Corson's Inlet North	39°13'	74°39'	LT
A80a dmi	Cape May	Cowpens Island	39°17'	74°35'	LBH, CATEG, SNEG, BCNH, GLIB, GBBG, HG
49a	Cape May	Crook Horn Creek	39°14'	74°49'	CT
65a	Cape May	Dead Thorofare	39°02'	74°40'	CT
74*	Cape May	Grassy Sound Channel North	39°01'	74°49'	LG,CT
73*	Cape May	Grassy Sound West	39°02'	74°49'	CT
62	Cape May	Great Flat Thorofare	39°03'	74°48'	GBBG, HG, LG

(Continued)

Table 6 (Continued)

Site No.	County	Name	Latitude	Longitude	Species Present
98B dmi	Cape May	Gull Island North	$39^{o}05'$	$74^{o}46'$	LBH, SNEG, LAH, GLIB, HG
98B dmi	Cape May	Gull Island South	$39^{o}05'$	$74^{o}46'$	SNEG, LAH, GLIB
59	Cape May	Ingram Thorofare	$39^{o}07'$	$74^{o}44'$	BLSK
75*	Cape May	Jenkins Channel	$39^{o}03'$	$74^{o}49'$	FT
56*	Cape May	Ludlum Thorofare	$39^{o}09'$	$74^{o}43'$	LG, FT
60	Cape May	Muddy Hole	$39^{o}04'$	$74^{o}46'$	LG
103 dmi	Cape May	Nummy Island	$39^{o}02'$	$74^{o}48'$	GBBG, HG, LG, CT
49*	Cape May	Peck Bay	$39^{o}02'$	$74^{o}37'$	LG, CT
68a	Cape May	Reubens Thoro	$38^{o}59'$	$74^{o}52'$	CT
61	Cape May	Ring Island	$39^{o}03'$	$74^{o}47'$	LG
64	Cape May	Seven Mile Beach	$39^{o}02'$	$74^{o}47'$	LT
66	Cape May	Shaw Cutoff	$38^{o}59'$	$74^{o}51'$	LBH, CATEG, GREG, SNEG, LAH, BCNH, GLIB, LG
109 dmi	Cape May	Shaw Island	$38^{o}59'$	$74^{o}51'$	YCNH, GLIB
A80b dmi	Cape May	Shooting Island	$39^{o}16'$	$74^{o}36'$	LG,CT
72	Cape May	South Cape May	$38^{o}50'$	$74^{o}50'$	CT, LT
57	Cape May	South Channel	$39^{o}07'$	$74^{o}44'$	CT
69	Cape May	S.W. Cove Point	$38^{o}58'$	$74^{o}52'$	HG, CT, BLSK
67	Cape May	Stingaree Point	$38^{o}59'$	$74^{o}51'$	GREG, LAH, BCNH, YCNH
63	Cape May	Stone Harbor	$39^{o}02'$	$74^{o}46'$	LBH, CATEG, GREG, SNEG, LAH BCNH, YCNH, GLIB

(Continued)

Table 6 (Continued)

Site	County	Name	Latitude	Longitude	Species Present
51	Cape May	Strathmere Bay	$39^{o}12'$	$74^{o}40'$	LG, CT, BLSK
98A dmi	Cape May	Sturgeon Island	$39^{o}05'$	$74^{o}46'$	GBBG, HG, LG
68	Cape May	Swain Channel	$38^{o}59'$	$74^{o}51'$	LG, FT, CT
55	Cape May	Townsend's Inlet	$39^{o}08'$	$74^{o}43'$	LBH, SNEG, LAH, BCNH, YCNH, GLIB, HG
70	Cape May	Two Mile Beach	$38^{o}57'$	$74^{o}51'$	LT
85 dmi	Cape May	Weakfish Creek	$39^{o}13'$	$74^{o}39'$	SNEG, BCNH, GLIB
54	Cape May	Whale Beach	$39^{o}10'$	$74^{o}41'$	LT
7	Ocean	Barnegat Head	$39^{o}46'$	$74^{o}07'$	LBH, GREG, SNEG, LAH, BCNH YCNH, GLIB
8	Ocean	Barnegat Inlet	$39^{o}46'$	$74^{o}06'$	LT
X47 dmi	Ocean	Barrel Island North	$39^{o}34'$	$74^{o}17'$	LBH, SNEG, BCNH, GLIB, CT
X47 dmi	Ocean	Barrel Island South	$39^{o}34'$	$74^{o}17'$	LBH, SNEG, BCNH, GLIB
21*	Ocean	Bunting Sedge	$39^{o}33'$	$74^{o}17'$	CT
5	Ocean	Buster Islands	$39^{o}48'$	$74^{o}06'$	CT
18 dmi	Ocean	Cedar Bonnet	$39^{o}39'$	$74^{o}12'$	LT
9	Ocean	Clam Island Complex	$39^{o}45'$	$74^{o}08'$	GBBG, HG, LG
A35 dmi	Ocean	East Carvel Island	$39^{o}41'$	$74^{o}10'$	HG, CT, BLSK
A43b dmi	Ocean	East Marshelder Island	$39^{o}35'$	$74^{o}14'$	CT
19	Ocean	Egg Island	$39^{o}38'$	$74^{o}13'$	GBBG, HG, LG, CT
40 dmi	Ocean	Flat Island	$39^{o}38'$	$74^{o}12'$	LBH, GREG, SNEG, LAH, BCNH, GLIB, HG
26	Ocean	Good Luck Sedge	$39^{o}33'$	$74^{o}18'$	CT

(Continued)

Table 6 (Continued)

Site	County	Name	Latitude	Longitude	Species Present
27 dmi	Ocean	Goosebar Sedge	$39^{o}32'$	$74^{o}17'$	LBH, SNEG, LAH, BCNH, GLIB, GBBG, HB
11a	Ocean	Gulf Point	$39^{o}44'$	$74^{o}10'$	CT, BLSK
A43a dmi	Ocean	Ham Island	$39^{o}36'$	$74^{o}13'$	CT, BLSK
13*	Ocean	Harvey Sedge East	$39^{o}42'$	$74^{o}10'$	HG
13*	Ocean	Harvey Sedge West	$39^{o}42'$	$74^{o}10'$	HG
9	Ocean	High Bar	$39^{o}45'$	$74^{o}08'$	LBH, SNEG, BCNH, GBBG, HB, LG
20*	Ocean	Hither Island	$39^{o}34'$	$74^{o}17'$	HG
28	Ocean	Holgate	$39^{o}31'$	$74^{o}17'$	CT, LT, BLSK
3	Ocean	Lavallette Island	$39^{o}59'$	$74^{o}05'$	CT
22	Ocean	Little Island	$39^{o}35'$	$74^{o}15'$	HG, CT
A43a	Ocean	Little Ham Island	$39^{o}36'$	$74^{o}13'$	CT, BLSK
15	Ocean	Log Creek	$39^{o}41'$	$74^{o}11'$	CT, BLSK
25	Ocean	Middle Island	$39^{o}34'$	$74^{o}17'$	LBH, GREG, SNEG, LAH, BCNH, GLIB, GBBG, HG, LG
24	Ocean	Middle Sedge	$39^{o}34'$	$74^{o}17'$	HG, LG, CT
1	Ocean	Middle Sedge Island	$40^{o}00'$	$74^{o}05'$	CT
23	Ocean	Mordecai Island	$39^{o}33'$	$74^{o}15'$	CT, BLSK
2	Ocean	N.W. Point Island	$39^{o}59'$	$74^{o}05'$	CT
45A dmi	Ocean	Parker Island	$39^{o}34'$	$74^{o}15'$	LT
A12 dmi	Ocean	Pelican Island	$39^{o}57'$	$74^{o}05'$	LT
16	Ocean	Pettit Island	$39^{o}40'$	$74^{o}11'$	CT
12	Ocean	Sandy Island	$39^{o}43'$	$74^{o}09'$	GBBG, HG

(Continued)

Table 6 (Concluded)

Site	County	Name	Latitude	Longitude	Species Present
11	Ocean	Sloop Sedge East	39°44'	74°09'	GBBG, HG
11	Ocean	Sloop Sedge West	39°44'	74°09'	GBBG, HG
21a*	Ocean	South Barrel Island	39°33'	74°16'	GBBG, HG, CT, BLSK
26a*	Ocean	Story Island	39°33'	74°18'	HG
10	Ocean	Vol Sedge East	39°45'	74°08'	HG, LG
10	Ocean	Vol Sedge West	39°45'	74°08'	HG, CT
14	Ocean	W. Carvel Island	39°41'	74°10'	HG, CT
A43b dmi	Ocean	W. Marshelder Island	39°35'	74°14'	HG

colony numbers recorded in Figure C2. Some colonies may share the same site number because of their proximity. Figure C2, a map of the specific study area, presents the locations and taxonomic composition of all colony sites. A summary of sites and species in June 1977 is presented in Table 7. Table 8 gives a breakdown of study island species, populations, and nesting substrate.

Census of Colony Sites

125. A total of 52,205 pairs of nesting colonial seabirds and wading birds were censused in June 1977 between Cape May and Manasquan Inlets. Eight species of wading birds, four gulls and four terns, and black skimmer nested in the specific study area. Laughing gulls were the most numerous with 35,241 pairs. Common terns were next with 4,667 pairs, followed closely by herring gulls with 4,202 pairs. Great black-backed gulls and gull-billed terns were rare, but they showed increases over 1976 figures (Appendix A) with 103 and 18 pairs, respectively. A total of 349 pairs of Forster's terns, 691 pairs of least terns, and 1352 pairs of black skimmers were censused. The latter two species have declined in New Jersey and both were unable to successfully produce large numbers of young in 1977. They have both been placed on the New Jersey State Endangered Species List, and steps are being taken to provide extra protection to them at their nesting sites (J. Galli, 1977, personal communication). Wading birds totalled 5,582 pairs, with snowy egrets (2094 pairs), glossy ibises (1543 pairs), and black-crowned night herons (627 pairs) the most numerous. Cattle egrets (431 pairs) were more numerous than great egrets (379 pairs). Little blue herons were more numerous in 1977 than in 1976, with 232 pairs. Louisiana herons and yellow-crowned night herons were least numerous, with populations of 151 pairs and 125 pairs, respectively. Figure 37 indicates the percentage of the total population represented by each species of wading birds.

126. All wading bird species were nesting in mixed colonies in interspecific associations. Least terns were not found nesting in association with any other species. Laughing gulls, while nesting with

Table 7

Colonial Seabird and Wading Bird Census and Survey Results {Cape May to Manasquan Inlet - June 1977}

Species	Breeding Population	# Colony Sites
Little blue heron	232	17
Cattle egret	431	6
Great egret	379	13
Snowy egret	2094	24
Louisiana heron	151	14
Black-crowned night heron	627	28
Yellow-crowned night heron	125	14
Glossy ibis	1543	23
Wading birds (total)	5582	
Great black-backed gull	103	21
Herring gull	4202	40
Laughing gull	35241	31
Gull-billed tern	18	3
Forster's tern	349	6
Common tern	4667	52
Least tern	691	15
Black skimmer	1352	14
Ground nesters (total)	46623	

Total Population: 52,205 pairs

Table 8

Colony Data on Study Islands

Colony No.	Species	Population pairs	Nesting Substrate
A12	least tern	240	sand, shell, gravel
A35	common tern	160	drift, marsh,grasses
	black skimmer	7	drift
	herring gull	1	grasses
45A	least tern	20	sand, shell, gravel
X27	snowy egret	22	shrubs
	glossy ibis	8	shrubs, reeds
	little blue heron	2	shrubs
	Louisiana heron	2	shrubs
	black-crowned night heron	4	shrubs, reeds
	herring gull	78	grasses, forbs
	great black-backed gull	5	grasses, forbs
A61c	little blue heron	25	shrubs, forbs
	cattle egret	30	shrubs, reeds
	great egret	30	shrubs, reeds
	snowy egret	75	shrubs, reeds
	Louisiana heron	15	shrubs, reeds
	black-crowned night heron	25	shrubs, reeds
	glossy ibis	100	shrubs, forbs, reeds
	herring gull	250	shrubs, grasses, forbs
	great black-backed gull	6	shrubs, forbs, grasses
85 dmi	snowy egret	6	shrubs, reeds
	black-crowned night heron	6	shrubs, reeds
	glossy ibis	4	shrubs, reeds
98A	great black-backed gull	3	grasses, reeds, shrubs
	herring gull	40	grasses, shrubs, reeds
	laughing gull	12	saltmarsh
98B North	little blue heron	4	trees, shrubs, reeds
	snowy egret	100	trees, shrubs, reeds
	Louisiana heron	2	trees, shrubs, reeds
	glossy ibis	75	trees, shrubs, reeds
	herring gull	20	grasses, shrubs
98B South	snowy egret	120	trees, shrubs, reeds
	glossy ibis	20	trees, shrubs, reeds
	Louisiana heron	1	trees, shrubs, reeds

(Continued)

Table 8 (Concluded)

Colony No.	Species	Population Pairs	Nesting Substrate
103	great black-backed gull	20	shrubs, reeds, grasses, forbs
	herring gull	400	shrubs, reeds, forbs, grasses
	common tern	32	saltmarsh drift
	laughing gull	950	saltmarsh
109	yellow-crowned night heron	20	trees, shrubs, reeds
	glossy ibis	4	trees, shrubs, reeds

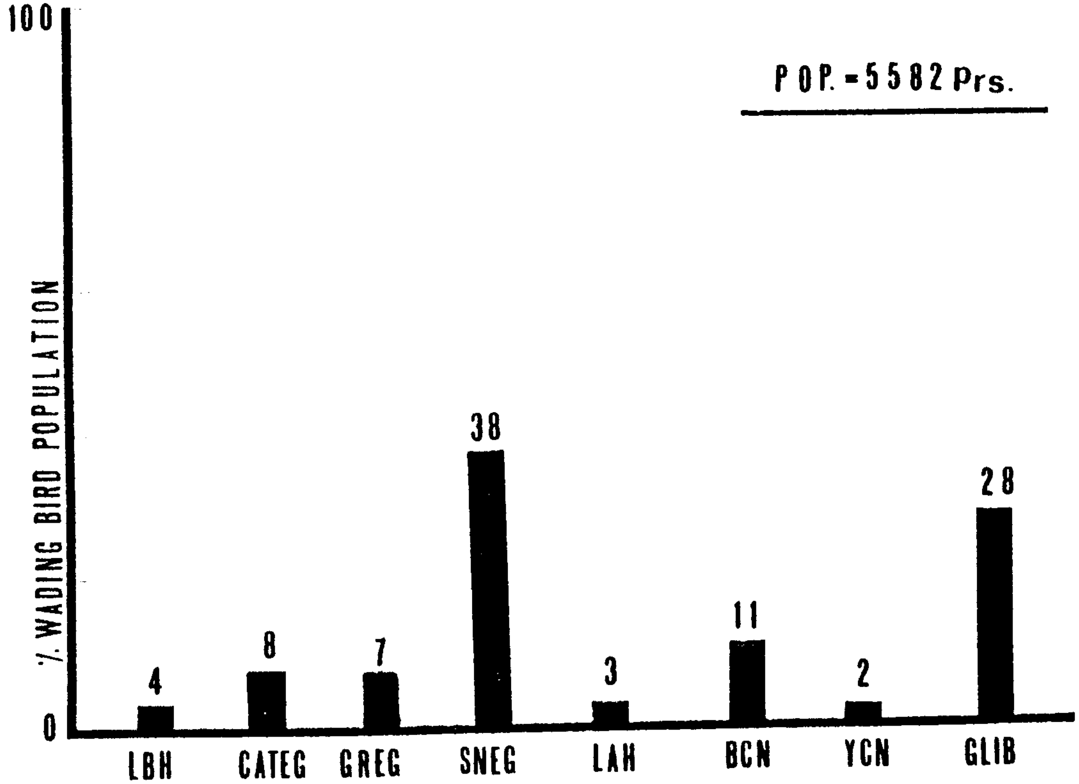

Figure 37. Wading bird species population distribution, showing percentages of species in the total New Jersey population. LBH= little blue heron; CATEG= cattle egret; GREG= great egret; SNEG= snowy egret; LAH= Lousiana heron; BCN= black-crowned night heron; YCN= yellow-crowned night heron; GLIB= glossy ibis

other breeding species (common terns, Forster's terns, herring gulls) nearby, did not form any positive nesting associations with other species: their proximity seemed to be more a function of nest site habitat than anything else. Black skimmers and common terns did seem to have a nesting site association, with common terns nesting at 13 of the 14 black skimmer sites. Herring gulls and great black-backed gulls also showed a positive nesting association at all 21 colony sites. Herring gulls seemed to show the greatest range in nesting associations and habitat tolerance. They occurred at colony sites with all other species except Forster's terns, gull-billed terns, and least terns. Herring gulls are rapidly expanding in New Jersey (Burger 1977b) and are heavily competing with laughing gulls and common terns for nest sites (Burger and Shisler 1977; Burger and Lesser 1976). They arrived earlier at their nest sites than other species, except great black-backed gulls, and were observed successfully preying on eggs and young in nearby heronries and tern colonies. Only great black-backed gulls seemed to be able to successfully out-compete them for higher, drier nesting spots in the marsh, probably by nesting earlier. Great black-backed gulls were more advanced in their nesting stages by 1 to 2 weeks, and most had well-developed young by June 1977.

General colony habitat

127. The general colony habitats supporting colonial nesting wading birds and seabirds in New Jersey were placed into 10 categories listed in Table 1. These categories were combined into four broader categories.

a. Marsh includes both salt marsh and salt marsh island for further analysis.

b. Dredged Material includes all dredged material islands, marsh islands with dredged material deposition, and salt marshes with dredged material deposition.

c. Barrier Island includes barrier spits as well as barrier islands.

d. Other refers to construction fill sites or natural sand shoals.

Table 6 summarizes the types of nest sites utilized by the species studied in June 1977.

128. Figures 38 through 47 indicate the species population and colony site distribution over four general colony habitat categories. Figure 38 shows that 47 percent of the total number of colony sites were found in marsh habitat, but 38 percent were located on dredged material sites. When the total breeding population which includes very large numbers of laughing gulls, herring gulls, and common terns (Table 7) is considered (Figure 39), the marsh habitat was clearly the most utilized, with 76 percent of the total population nesting in marsh and only 18 percent on dredged material. In both cases the barrier island habitat was the least utilized. Analysis of the breeding population by species gives a more precise picture of the importance of each type of habitat.

129. The wading birds did not utilize marsh habitat at all. During the 1800's they nested in very large colonies on the then-wooded barrier islands. Figures 40 and 41 show that dredged material islands are now the most important habitat for heronry sites. Seventy-one percent of the wading bird population and 75 percent of their colony sites were located on dredged material sites. Barrier islands retain some importance, since 28 percent of their population and 22 percent of their colony sites are located there. One colony is located on construction fill near Atlantic City.

130. The importance of dredged material islands as colony sites for wading birds is further supported by closer analysis of the individual heron species population and colony site distributions. In all species, at least half their colony sites were located on dredged material (Figure 42), though barrier islands were also important. The population distribution levels were similar to colony site distribution, although barrier island colonies supported greater populations of certain species (great egrets, black-crowned night herons, yellow-crowned night herons) than the other sites. However, dredged material colony sites supported 91 percent of the snowy egret, 75 percent of the glossy ibis and 68 percent of the little blue heron populations (Figure 43).

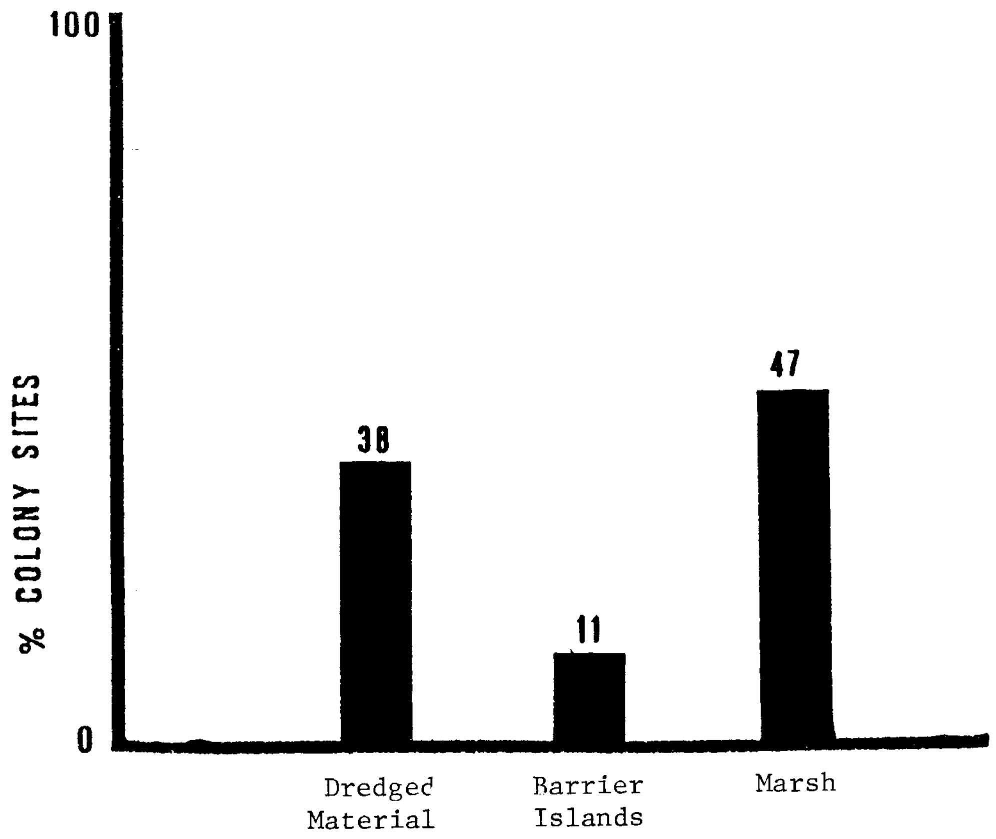

Figure 38. Colony site distribution, showing percentages of total sites on three different habitats

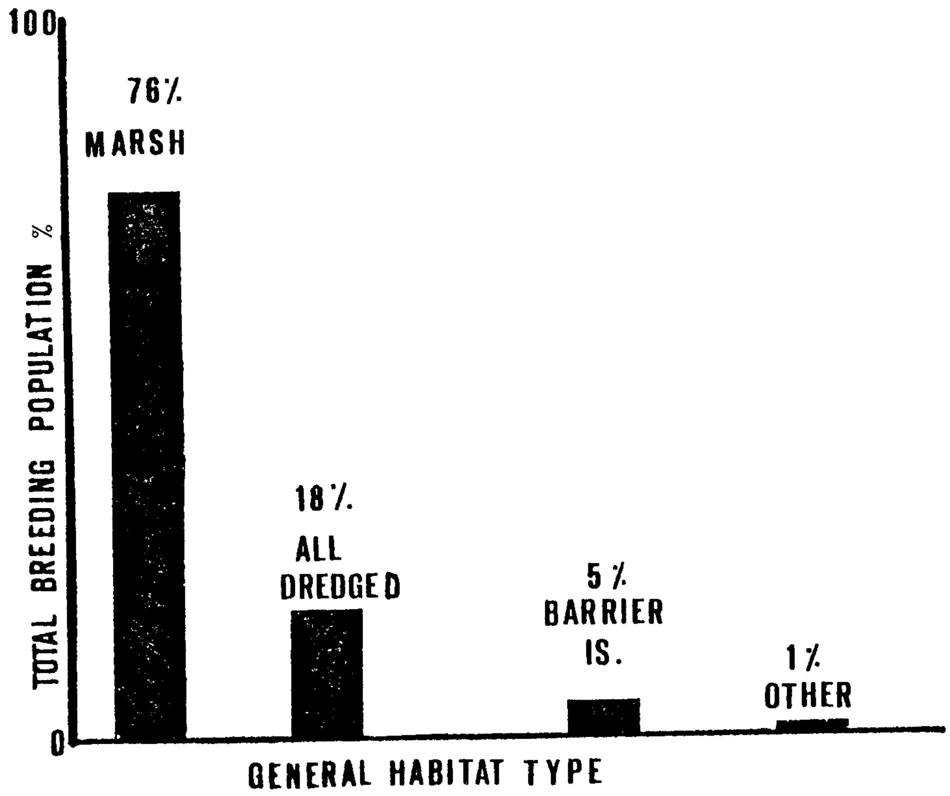

Figure 39. Population distribution of colonial waterbirds in New Jersey, showing percentages using four different habitats

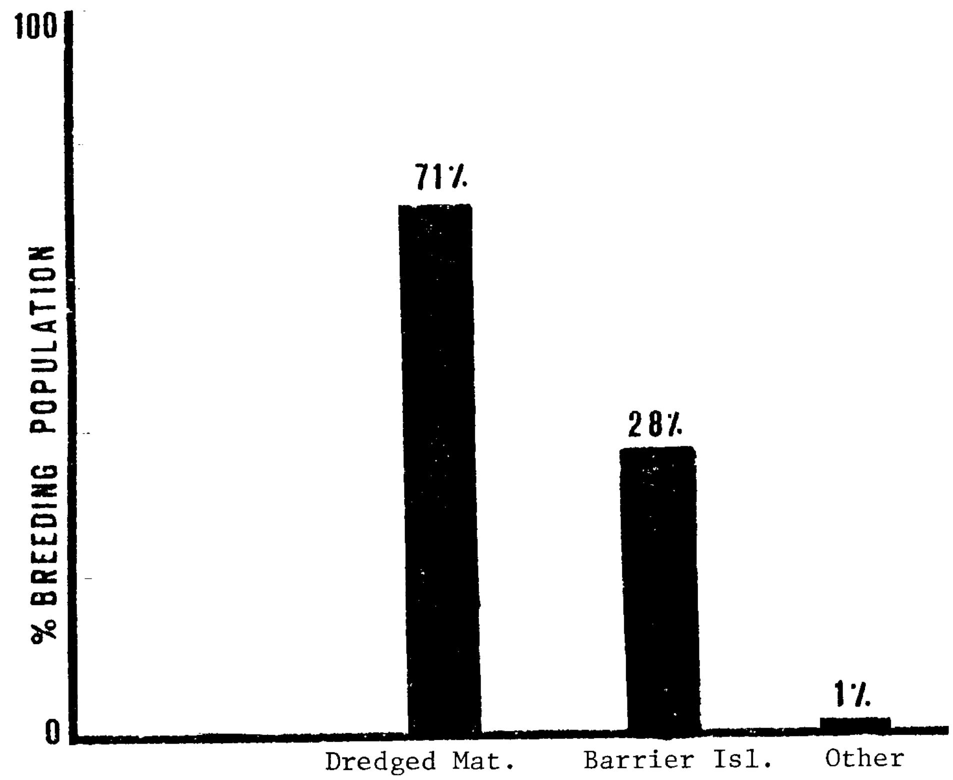

Figure 40. Wading bird distribution, showing percentages of use of three habitats

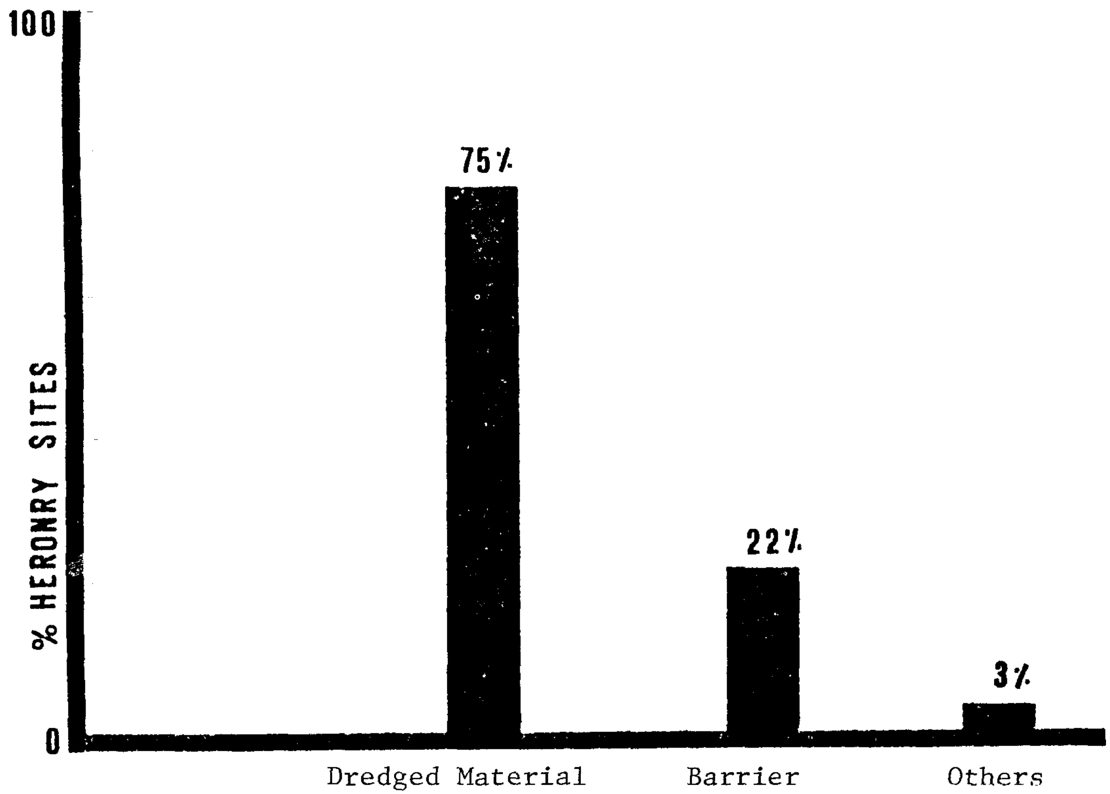

Figure 41. Wading bird colony distribution, showing percentages of colonies occurring on three different habitats

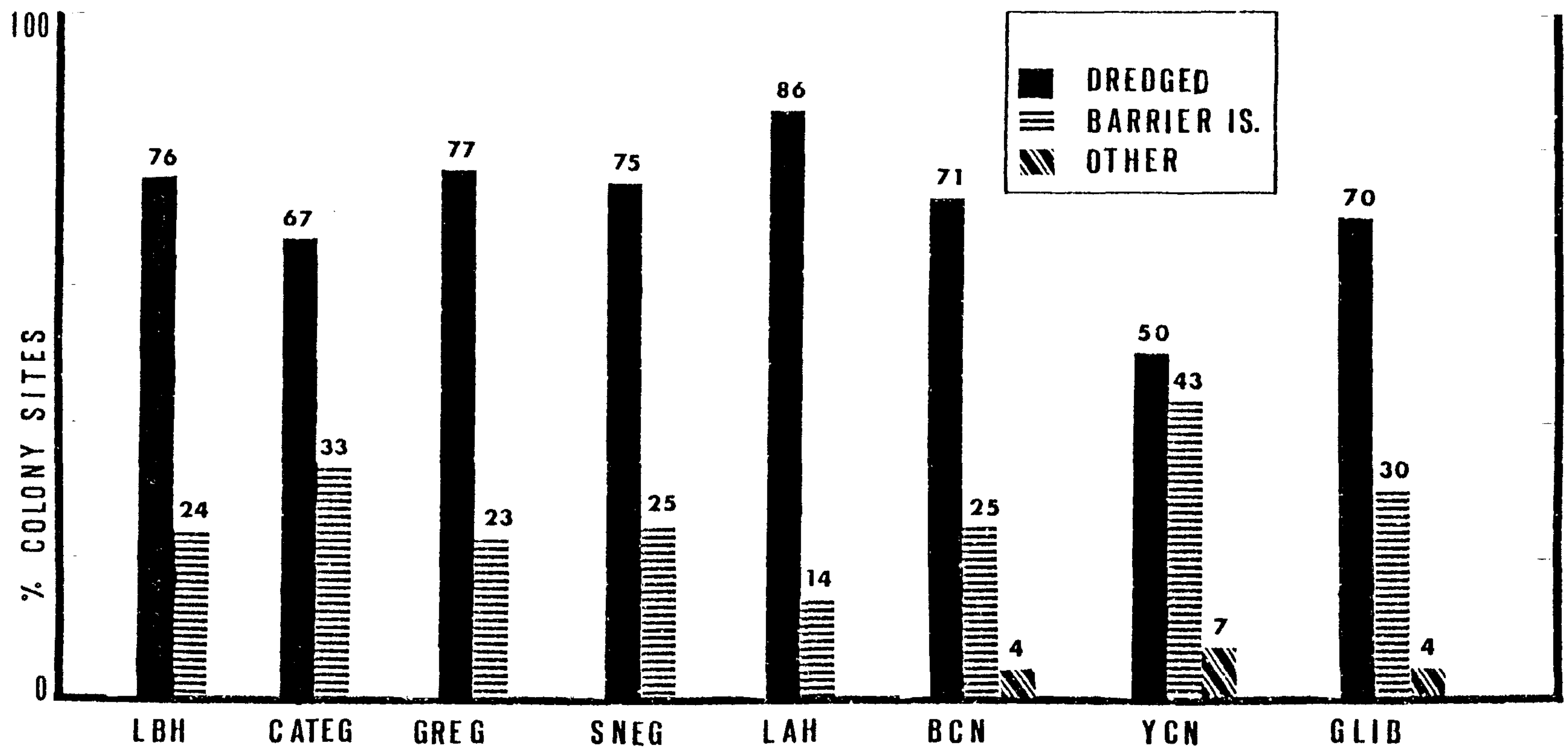

Figure 42. Wading bird colony habitat distribution by species, showing percentages of colonies in three different habitats. LBH=little blue heron; CATEG=cattle egret; GREG= great egret; SNEG= snowy egret; LAH= Louisiana heron; BCN= black-crowned night heron; YCN= yellow-crowned night heron; GLIB= glossy ibis

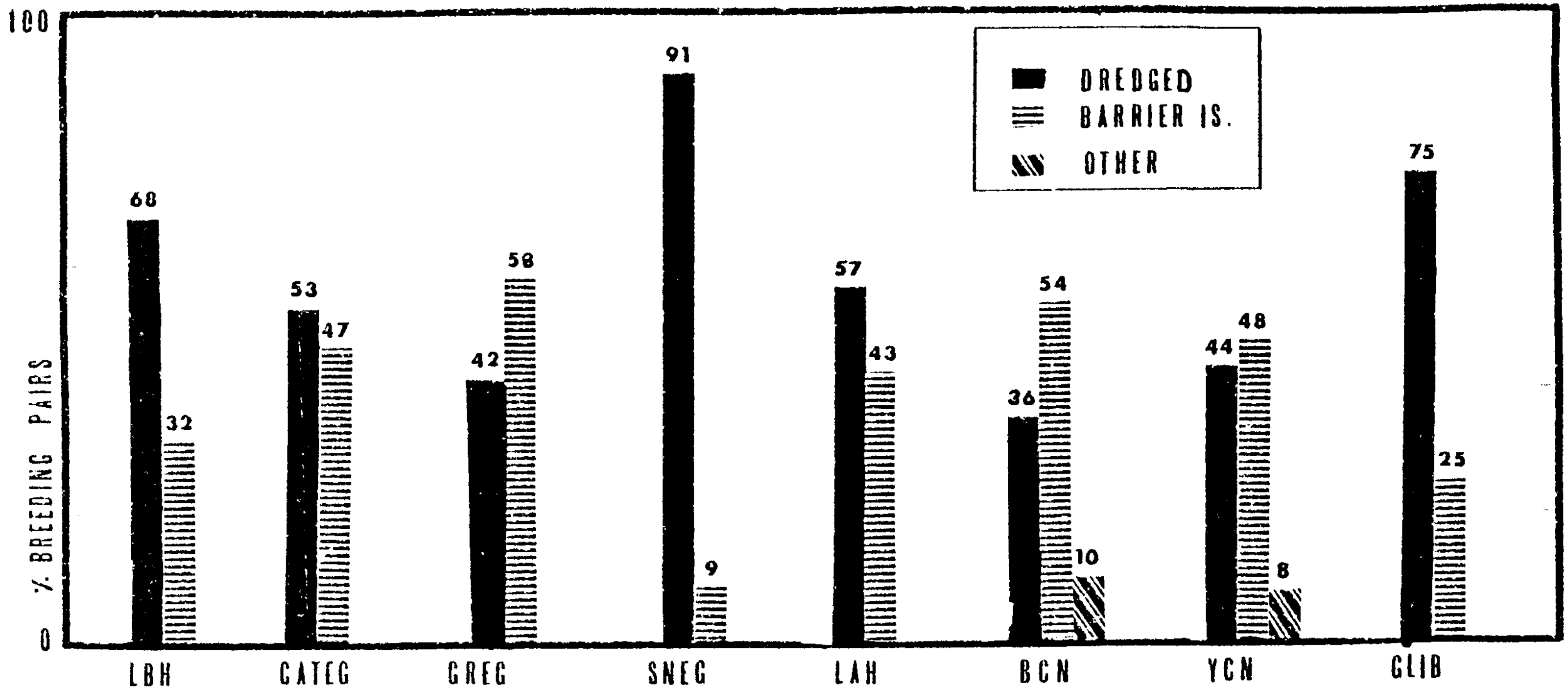

Figure 43. Wading bird species distribution by colony habitat, showing percentages of breeding pairs. LBH= little blue heron; CATEG= cattle egret; GREG= great egret; SNEG= snowy egret; LAH= Louisiana heron; BCN= black-crowned night heron; YCN= yellow-crowned night heron; GLIB= glossy ibis

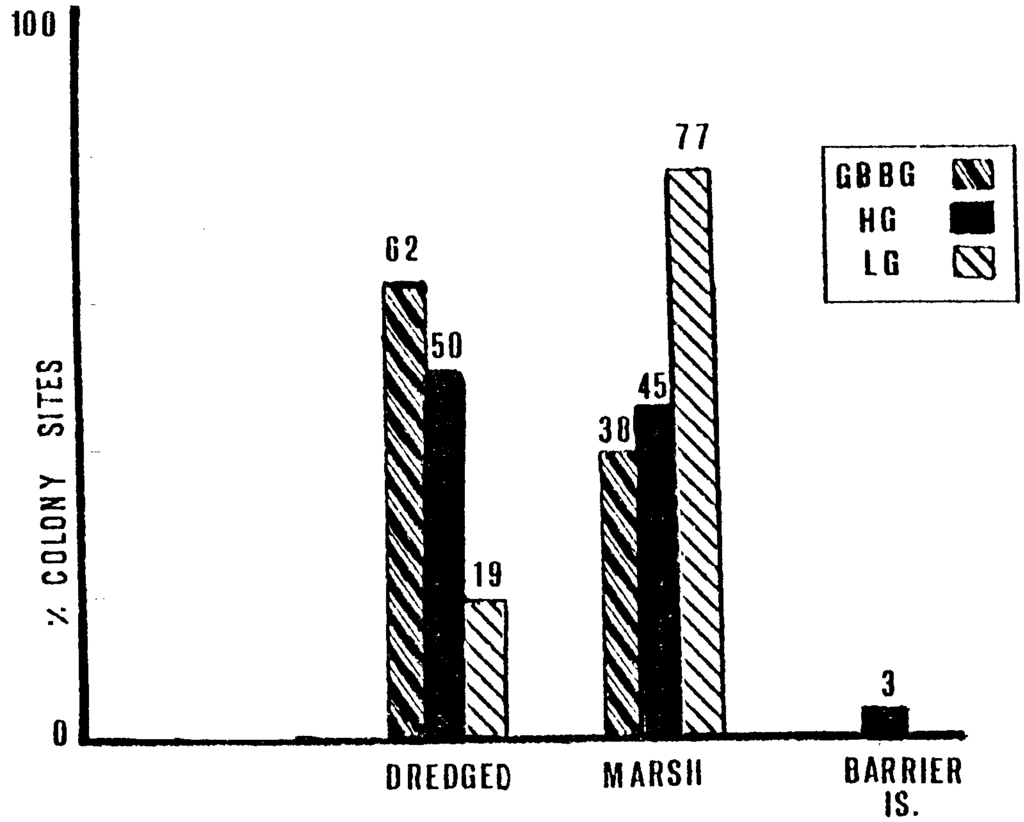

Figure 44. Gull colony habitat, showing percentages of colony sites on three different habitats. GBBG= great black-backed gull; HG= herring gull; LG= laughing gull

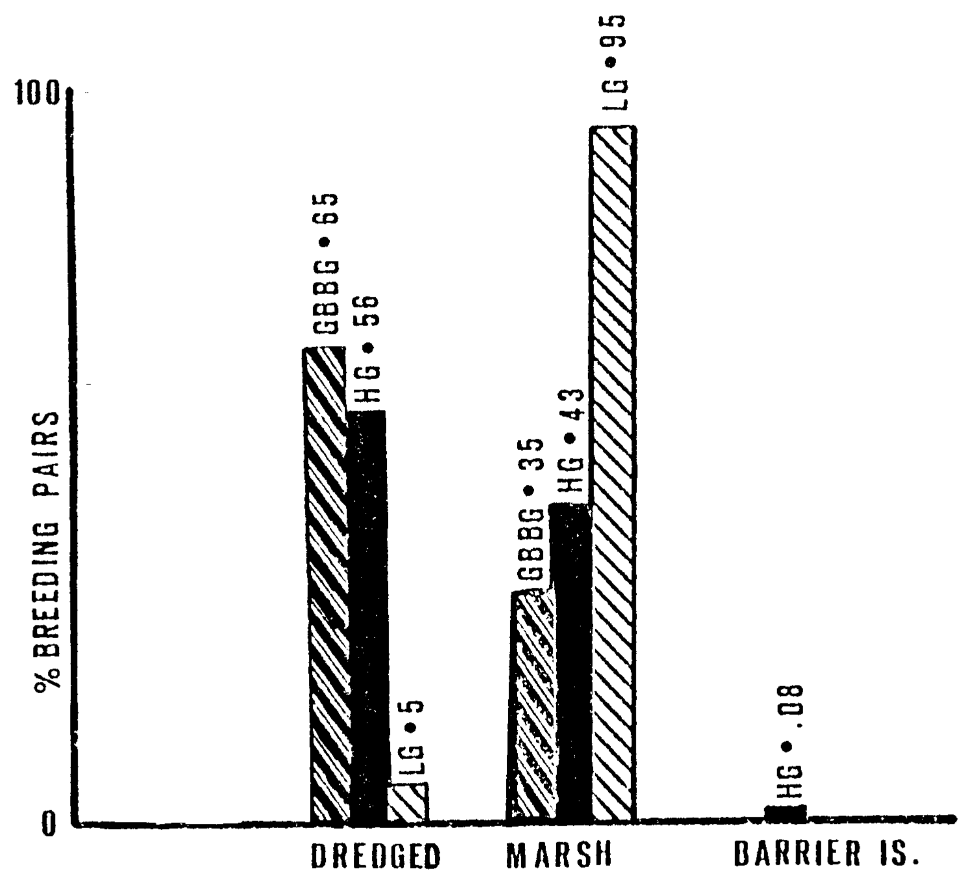

Figure 45. Gull species distribution by colony site habitat, showing percentages of all three gull species use of three different habitats. GBBG= great black-backed gull; HG= herring gull; LG= laughing gull

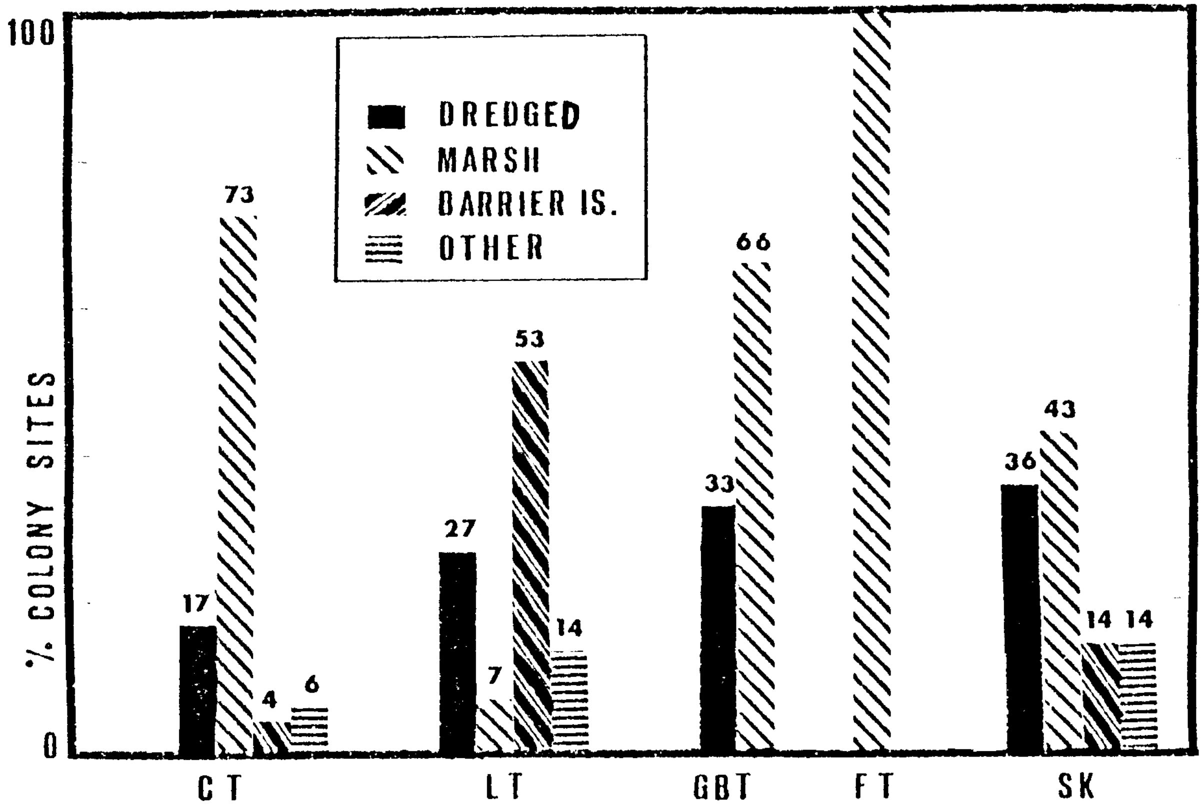

Figure 46. Tern-skimmer colony habitat, showing percentages of colony sites by species. CT= common tern; LT= least tern; GBT= gull-billed tern; FT= Forster's tern; SK= black skimmer.

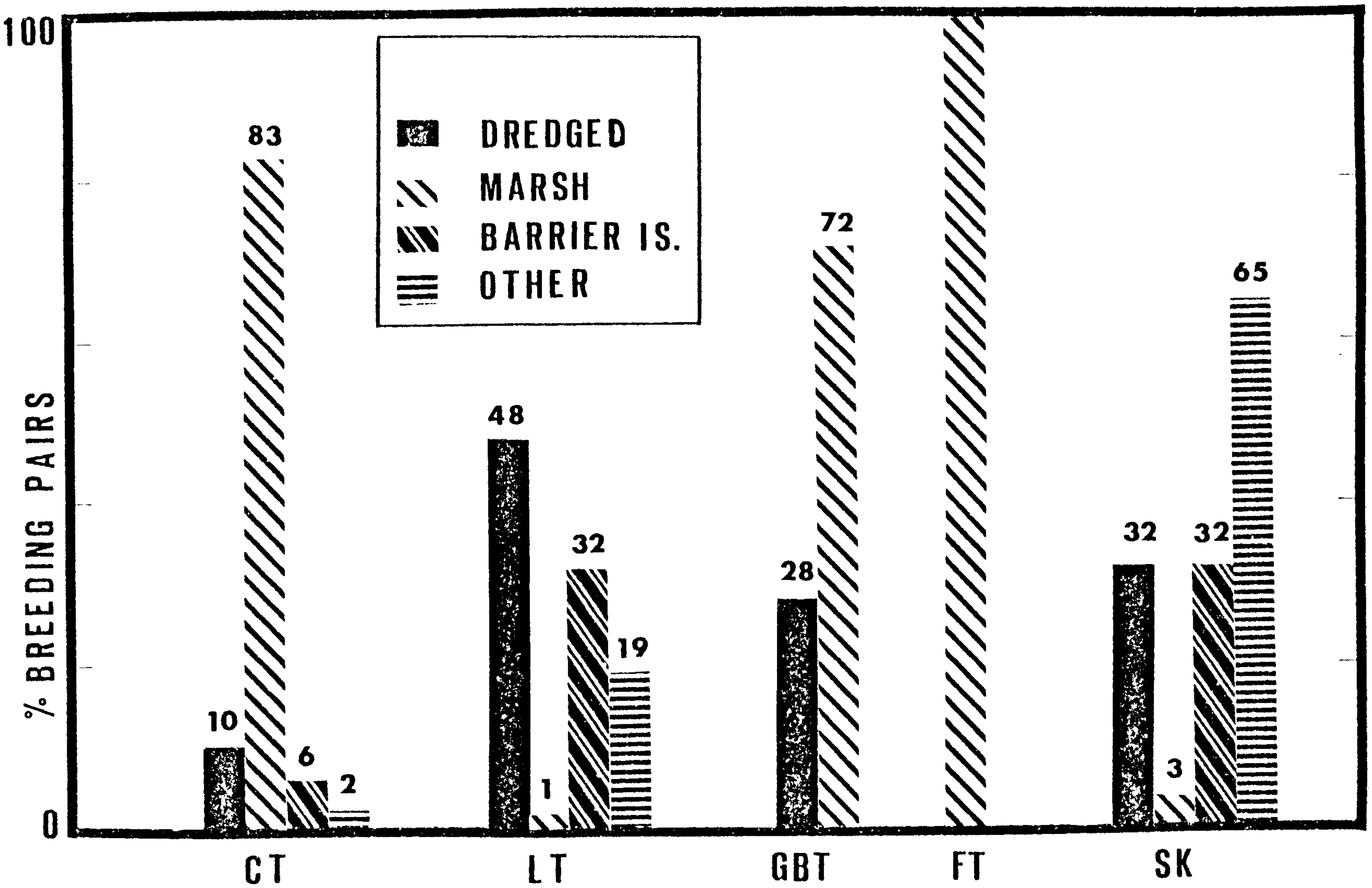

Figure 47. Tern-skimmer species distribution by colony site habitat, showing percentages of breeding pairs by species on four different habitats. CT= common tern; LT= least tern; GBT= gull-billed tern; FT= Forster's tern; SK= black skimmer

Differences between the population and colony site distribution over dredged material islands and barrier islands reflects the very large Stone Harbor heronry compared to smaller colonies limited by cover size on younger dredged material islands. This accounts for use of a greater number of dredged material islands compared to barrier islands, with shrinking available habitat.

131. The three gull species utilize differing habitats for colony sites. While laughing gulls always nested on salt marsh, Figure 44 and 45 show that 19 percent of their nest colony sites and 5 percent of their breeding population were associated with dredged material, either on salt marsh adjacent to dredged material that had either eroded or been deposited at low enough elevations for salt marsh to develop. The 77 percent of colony sites and the 95 percent of the breeding population on natural salt marsh leave no doubt that in New Jersey salt marsh is the habitat most used by nesting laughing gulls.

132. Figures 44 and 45 show that dredged material islands are the most utilized nesting sites for great black-backed gulls and herring gulls,supporting 62 percent of the great black-backed gull colonies with 65 percent of the population, and 50 percent of the herring gull colonies with 56 percent of the population. Despite the expansion of herring gulls and great black-backed gulls into salt marsh nesting areas (Burger 1977) and the adaptability of herring gulls to a wide variety of habitats, most of those in the marsh were nesting on small, dredged material mounds on the sides of ditches dredged for mosquito control. Herring gulls were also found nesting on the barrier beach in small numbers.

133. Marsh habitat is of major importance to Forster's terns and gull-billed terns in New Jersey. Forster's terns nested on drift in salt marsh areas, and showed no relationship to dredged material islands (Figures 46 and 47). Gull-billed terns, though having 28 percent of their breeding population and 33 percent of their colonies on dredged material, are a marsh nesting species in New Jersey. Their nests were on salt marsh drift. One (Oyster Thoro Marsh {#61}) of the three nesting sites was on a badly eroded deposit that had developed into salt

marsh.

134. Common tern colonies and breeding pairs were also predominantly found in marsh habitat. Figure 46 shows that 73 percent of their colony sites were located in marsh habitat and natural sand shoals on dredged material. Barrier island habitat and natural sand shoals account for a small portion (10 percent) of the 52 sites. Population numbers (Figure 47) show that marsh habitat is very important in New Jersey, with 83 percent of the common terns on marsh and only 10 percent associated with dredged material. Barrier island habitat accounted for only 6 percent of the population. The major portion of colony sites were on salt marsh grasses and drift including those on dredged material islands.

135. Least terns nested on dredged material islands, on barrier islands, on sand shoals, and on mainland sandy beach, with 53 percent of their colony sites on barrier island beaches (Figure 46). Dredged material was used by 27 percent of their colonies. Sites noted as marsh in Figure 46 were actually sandy areas in marsh behind the barrier beach. Population distribution data, however, showed some differences in habitat utilization from colony site data. Dredged material sites were used by 48 percent of the population, with barrier islands being used by 32 percent. The differences between colony site and population percentage distributions over habitat types reflects the presence of a large colony on dredged material Study Island A12, which supported the largest least tern colony in New Jersey in 1977.

136. Black skimmers nested on dredged material sites, marsh, barrier islands, construction fill, and natural sand shoals. Figures 46 and 47 show that barrier islands supported 14 percent of the colonies and 32 percent of the population. Dredged material sites were also important, having 36 percent of the colonies and 32 percent of the population. Comprising only 14 percent of the colonies, two sites held 65 percent of the population: one on construction fill and another on a natural sand shoal. Each site supported large populations (400 and 450 pairs, respectively). Nesting black skimmers associated frequently with common terns, even in salt marsh colonies, though in small numbers. In

1977, 42 pairs were located in marsh colonies with common terns. Their nests were on salt marsh drift rather than the sand and shell usually associated with skimmers.

Comparison of Vegetation on Study Islands with and without Bird Colonies

137. Analysis of data indicated that there are no significant differences of average frequency, cover or height scores, and visibility indices between bird (colony) and vegetation (non-colony) dredged material islands. Reed, reed-shrub, shrub, dense grassland, shrub-dense grassland, and shrub-forest habitats were found on study islands in New Jersey in greater numbers and distributions in bird colonies. They are probably the most important plant communities on the study islands.

138. In comparisons of hectares of habitat on all bird islands vs. all vegetation islands, only bare habitat occurred in significantly greater size and percentages on bird study islands. Adequate bare-sand habitat usually favored by least terns, common terns, black skimmers, and to a lesser extent by herring gulls, is very scarce on dredged material islands along the New Jersey Intracoastal Waterway. These species are forced to nest in probably marginal habitat such as drift.

139. Other analyses showed no significant differences between plant communities with or without colonies.

PART IV: DISCUSSION

140. Numerous dredged material sites exist between Cape May Inlet and Manasquan Inlet. Of these, at least 25 sites supported colonial nesting seabirds and/or wading birds. The dredged material sites were not all discrete islands: some were areas of marsh that had dredged material deposits and some were large diked areas connected to land. They ranged in size from 1.6 ha to 129.3 ha and in known age from one to at least seventeen years. Although dredging has caused island formation in New Jersey for at least 75 years, dates of deposition are unknown. The 21 dredged material study islands ranged in size from 0.6 to 4.0 ha and in age from 1 to 14 years. Only three of the study islands were diked. The diking of dredged material disposal sites is currently the only method of disposal permitted in New Jersey, and these three sites had the most recent dredged material depositions of those studied.

141. Vegetation on the islands ranged from none (bare sand or sand/shell/gravel), to salt marsh grasslands, to upland grasslands, to developing shrub and shrub-forest communities. Colonial nesting waterbird species were found in most of the plant communities as well as on bare sand. Data indicated that other factors besides age of the dredged material site greatly influenced the plant succession patterns presently found at the study sites.

Plant Succession

142. Dredged material islands provided a wide range of habitat and exhibited all stages of vegetation common to the barrier beaches and salt marsh areas of the outer coastal plain of southern New Jersey. Their deposition on tidal salt marsh provided upland vegetation with conditions favorable to growth in places where previously there had been none. In some instances marsh areas were increased by the sediment deposition in shallow waters. In other areas, preexisting salt marsh was destroyed and the resulting upland habitat was then claimed

by large stands of common reed. Vegetation and successional patterns on the dredged material study sites seemed to conform fairly closely to vegetation communities and successional patterns already described by Martin (1959), Chapman (1960), Robichaud and Buell (1973), and Daiber (1974) for the salt marshes and barrier islands of southern New Jersey.

143. Early seral stages were represented by bare, sparse grassland, dense grassland, and reed habitat. Species tolerant of saline and marsh conditions tended to be the colonizing or pioneering types. Mid seral stages were typified by young reed-shrub and shrub-dense grassland communities. Late seral stages were characterized by shrub and shrub-forest communities which occurred on the higher upland portions of older dredged material islands not subject to periodic flooding and lacking high soil salinity.

144. Early seral stages were found on islands varying in age from one year to at least 12 years old (deposition from 1965-1976). Mid seral stages were found on deposits 9 to 14 years old (deposition 1963-1968). Dredged material islands utilized from 1963-1966 (11 to 14 years old) exhibited late seral stage vegetation. Only the diked study islands had a single seral stage present. The others showed a combination of seres in diverse patterns. Factors other than age also influence successional stages found on these islands and probably account for variation between age and overlapping seres found on study islands. Martin (1959), studying vegetation at nearby Island Beach, found that vegetation types and patterns correlated closely with topography. He found that soil condition, salt spray distribution, salt spray tolerance, and water table levels also influenced vegetation and succession patterns, though he considered them to be subordinate to microtopographical effects. Daiber (1974) believes that tidal inundation, water levels, and salinity are of prime importance in determining vegetation patterns in salt marsh areas.

145. All these factors played a role in determining the varied and overlapping communities found on the study islands and the early stage vegetation exhibited on many islands despite their age. Martin (1959) attributed the stability and persistence of pioneer communities

in the most extreme habitats of xeric, mesic, and hydric zones to the inhibition of autogenic succession by physical factors, especially salt spray. Bare domes, extensive salt marsh vegetation, storm tide flooding, and dead vegetation found on many of the older study islands supports some of these factors as causes for the lack of correlation between seres and age. Investigation of the role played by these factors is needed over a longer period to determine the major influences on succession on dredged material islands in New Jersey.

Plant Comparisons Between Study Islands with and without Colonies

146. Dredged material study islands were remarkably similar in all parameters measured. No significant differences in vegetation frequency, cover, or height were found for any of the plant communities. Visibility indices derived for study islands also showed no significant differences. The qualitative occurrence of communities across all study islands and across pooled vegetation islands. Study islands with bird colonies did have a uniform distribution of plant communities when their data were pooled. Some communities were disproportionately represented on the bird study islands (reed, reed-shrub, shrub, and shrub-forest), probably due to the preponderance of bird study islands supporting heronries that were selected for study. The paucity of bare habitat along the New Jersey Intracoastal Waterway made it the most critical habitat to provide for nesting.

147. Heron colonies did not differ among themselves in proportional representation of plant communities. Herring gulls were heterogeneous with respect to their use of plant communities for nesting across all study islands. Heron density, deposit size, and deposit age comparisons showed no significant differences.

148. Other factors (not determined in this study) are of real importance in the selection of dredged material islands as nesting sites by colonial seabirds and wading birds, once minimal plant community habitat requirements are met.

Bird-Plant Associations

149. The plant communities occupied by nesting birds on dredged material study islands are summarized in Table 9. Examination of the plant communities present on the study islands shows that correlation of nesting birds to sere is difficult because of the presence of several communities. Only least terns showed a decided preference for a single seral stage, nesting in bare and sparse grassland communities. Least terns were found at only two study sites (45A and A12), but observation of other colony sites in the study area indicated that the sparse grassland on A12 was the most densely vegetated nesting situation.

150. The only common tern colony on the study islands occurred on the largest aggregate of dense grassland/drift communities found on all study islands, although the colony included intertidal, reed, reed-shrub, shrub-dense grassland, and shrub communities within its boundaries as well. Observation of other colony sites indicated that salt marsh drift and sand were frequently used as nest sites in the study area. Black skimmer data are limited since they occurred on the same study island (A35) with the common terns and only on salt marsh drift, an unusual nesting habitat for skimmers.

151. Herring gulls were the most diverse in their choice of colony habitats. Colonies on five study islands (X27, A61c, 98A, 98B North, 103) exhibited the widest range of plant communities within colony boundaries of all species studied. Communities representative of early, mid and late seral stages were included. Their wide choice of nesting habitat and expanding population made establishing preferences based upon study island colonies difficult. Despite the presence of 23 pairs of great black-backed gulls within four of the study island gull colonies (103, 98A, A61c, X27) in 1977, their habitat preferences could not be determined. Nesting chronology was too advanced when first observed.

152. The herons showed a definite preference for the reed, reed-shrub, shrub, and shrub-forest communities. The extensive stands of common reed, and the adaptability of certain wading bird species (glossy

Table 9

Plant Communities on Study Island Colony Sites

Species	Community	No. Colony Sites
Herons*	P	3
	PS	5
	S	4
	SF	3
Herring gulls	I	1
	B	1
	D	1
	GD	2
	P	2
	PS	2
	SGD	1
	S	3
Common terns	Drift	1
	I	1
	P	1
	PS	1
	SGD	1
	S	1
Least terns	B	1
	GS	1
Black skimmers	Drift	1

* includes herons, egrets, ibises

B = bare; I = intertidal;D = dike; GD = dense grassland; GS = sparse grassland; SGD = shrub-dense grassland; S = shrub; P = reed; PS = reed-shrub; SF = shrub-forest ibis, snowy egret, black-crowned night heron) made the wading bird population associated with early, mid and late seral stage vegetation at the six study island colonies. Use of reed for nesting at three colonies should not be regarded as an indication of the desirability of it as a heron nesting habitat. Colony site data showed that while some nests were in reed, many nests were found on woody shrubs (often only 1.5 m high) scattered through the reed. The developing shrub and shrub-forest communities on many of the older dredged material sites in New Jersey offer future wading bird populations numerous colony site choices compared to the scarcity of the bare sand habitats available for tern and skimmer populations.

153. The other colonial seabird species (laughing gull, Forster's tern, and gull-billed tern) nested in salt marsh habitats, most often upon drift, and were not often associated with the study islands.

Bird Effects Upon Plants

154. The effects that colonial bird species have upon vegetation at their colony sites have been studied by other researchers (Weise 1978, Burger 1976, Soots and Parnell 1975a and 1975b, Shanholtzer 1974, Ranwell 1972). Wiese (1978) found that extensive areas of a large mixed species heronry on Pea Patch Island, Delaware (a dredged material island colony that probably acts as a seed colony for several of the New Jersey heronries), were destroyed or defoliated by guano deposition by the birds during 1975 and 1976. The vegetation most affected was blueberries (*Vaccinium* sp.), though all herbaceous ground cover was also destroyed. The following season there was an invasion of nitrophilous species such as bluestem and elderberry, and nesting density was greatly decreased because of the loss of the preferred shrub for nesting locations. Weise also found that the birds' mechanical destruction of the vegetation in nest construction added to the defoliation of vegetation at site. Miller (1943) refers to the effects upon vegetation of great blue heron excrement, noting that red maple (*Acer rubrum*) seemed particuarly sensitive at colonies in Salem County, New Jersey.

155. Observations in 1977 at wading bird colony sites in New Jersey did not indicate extensive damage as described by Wiese (1978) but dead and/or bare vegetation, particularly in the understory at barrier island sites, was noticeable. Dredged material sites showed less damage, although vegetation used for nesting was younger and of slightly different species composition and dominance than the well-developed maritime forests common in barrier island colonies. The wading birds' greatest long-tern influence on vegetation growth patterns is probably through fecal enrichment of the soil.

156. Fecal enrichment of colony substrates has been noted in Europe where plant growth on normally open dune areas was changed by gulls into a "lush carpeting growth of weed species" (Ranwell 1972). The gulls also aided seed transport by carrying seeds in pellets regurgitated at the nest site. Burger (1976) found that black-headed gulls (*Larus ridibundus*) in England influenced the growth of nettles (*Urtica* sp.) tolerant to high nitrogen levels at colony sites over the native grasses preferred by the gulls. Soots and Parnell (1975a and 1975b) studied the changes in vegetation due to fertilization of North Carolina colony sites by royal terns (*Sterna maxima*), black skimmers, gull-billed terns,and common terns. This effect was suspected in New Jersey at the least tern colony on Island A12 (also a colony in 1976). The sparse vegetation growing on the dome slopes was probably encouraged by the fertilizing effects of the colony. Presence of a large least tern colony in an area as densely vegetated as this is unusual, and the site will probably not be suitable much longer for least terns.

157. Vegetation trampling and compression at colony sites has also been noted by several authors (Burger 1976, Soots and Parnell 1975a and 1975b, Shanholtzer 1974). The movement of many birds in and out of the same area and the placement of nests compresses the vegetation and retards its growth. This effect was most noticeable in the gull colony on Island 98A, where runways through the taller grasses between nest sites and an open grassy area used for loafing and maintenance activities were quite obvious. The physical damage to vegetation by nest-building activities, where plants are mechanically destroyed by

being trampled, by being pulled down and woven into a nest platform, or by being broken off at their stems and/or uprooted, can also have devastating effects upon the establishment of vegetation at colony sites.

158. The colonial species studied at the dredged material sites are probably not major seed vectors between islands and the mainland. However, they could influence seed dispersal of some species by carrying seeds in plumage or other body parts and disseminating them during maintenance activities that are often performed away from nests sites.

PART V: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

159. A complete inventory of dredged material island locations, origins and ages is needed in New Jersey. Repeated deposition of dredged material over the years on New Jersey salt marshes and islands, the irregularly shaped and eroding deposits, the overlapping plant communities and seral stages, and large stands of common reed all made correlation of plant seres with the age of study islands essentially impossible. Data indicated that other unstudied factors such as island microtopography would have been more useful in determining plant successional patterns. Dredged material islands in New Jersey do not fit the concentrically zoned bands found by Soots and Parnell (1975a, 1975b) in North Carolina, and Carlson (1972) in Florida. Instead, they present mosaic patterns similar to those described by Martin (1959) for Island Beach, NJ, and Ranwell (1972) for dune and salt marsh communities in these situations and should be the subject of future investigations. Microtopography, water table levels and salinity, salt spray tolerance, tidal flows, soil salinity, and species composition are among the factors that should also be considered.

160. Few significant differences were found between vegetation communities and their distribution on dredged material study islands with and without bird colonies. However, bare sand habitat was more common on bird study islands. Little new information was gained from the bird-vegetation associations studied beyond that already available in the general literature, especially for southern New Jersey (Appendix A).

161. There is little doubt that dredged material islands are important colony sites for wading birds and seabirds in New Jersey. The increasing development of barrier islands, resulting in habitat loss and disturbance, mandate the use of alternative colony sites by colonial nesting species. Dredged material islands can provide and are providing needed habitat alternatives for these species. Management of

these island sites in a manner designed to encourage the presence of desired wildlife species must be carried out if New Jersey is to maintain any semblance of once abundant and rich coastal wildlife resources.

Recommendations

162. Management recommendations made here, while formulated with specific reference to New Jersey dredged material islands, may also have broader applicability, especially in other estuarine areas where dredged material island management to provide and protect wildlife resources is desirable. The following recommendations are based upon investigations in New Jersey for this study, but are also based in part upon prior experience and investigations elsewhere along the Atlantic Coast.

General recommendations

163. The following recommendations are not necessarily listed in order of importance. They should be considered individually and together to provide a cohesive and practicable management program. They are:

- a. Inventory of dredged material islands. A complete investigation of dredged material island locations, origins, and ages based upon scientific methods such as coring, is needed in New Jersey. County historical records, title deeds, and historical navigation records should also be investigated as possible sources of information. Ownership should also be determined so that permission could be sought for management procedures, if necessary.

- b. Timing of dredged material deposition. The nesting season in New Jersey for colonial species extends generally from mid-March through 31 August and sometimes to late September (especially for black skimmers). Efforts should be made to carry out dredging operations during non-nesting times.

- c. Wildlife survey of dredged material sites. Before any dredging is begun, a survey of the disposal area should be made to determine the location of any nesting bird species. If colony sites are located at planned disposal areas, dredging should be delayed until after the nesting season, or an alternate site should be used.

d. Contractor monitoring. Once choice of a disposal site is made, careful and frequent onsite monitoring should be made to ensure that (1) the site being deposited upon is actually the designated location; (2) proper procedures are being used so that overspills and dike breakages are prevented, or are immediately corrected if they occur; (3) colonial nesters have not selected the site for nesting between the time of site designation and onset of dredging.

e. Record keeping. Careful records should be kept of all dredged material disposals, with dates, location, configuration, area covered, quantity, and sediment composition noted.

f. Integration of inlet dredging with Intracoastal Waterway dredging. Badly needed clean sand is often dredged from inlets. Use of this sand on dredged material islands in areas along the Intracoastal Waterway where contaminated or undesirable fines and clay sediments are dredged and deposited would be beneficial. The clean inlet sand could be used to cover the less desirable sediments, thereby providing useful and productive wildlife habitat.

g. Cooperation with other agencies. The interests of many other Federal, State, and local agencies are affected by the dredged material disposal activities of the Corps of Engineers. Mutual aid and information exchange at both national and local levels between all mutual interest groups are necessary before any management program can be effective. The sharing of expertise and genuine cooperative efforts for the formulation of an ecosystem-wide management plan for dredged material islands would benefit all, especially the wildlife. Environmental interest groups such as National Audubon Society and researchers should be included in any management planning so that all viewpoints would be considered.

h. Educational programs. An educational program should be instituted to acquaint key people at both the national and district levels with the wildlife value (potential and present) of dredged material islands and the consequences of less-than-careful dredged material disposal practices, especially upon species utilizing these sites during breeding seasons. Potential problems, solutions, and minimal operational changes (such as delaying disposal activities until after the breeding season) should be emphasized. An effort should be made to acquaint dredging contractors with potential wildlife resource problems as well. Organizations and personnel preparing environmental impact statements should be provided with data so that they are aware of the multiple wildlife use of these sites. Ecological awareness should also be encouraged.

i. Research needs. This study investigated the use of dredged material islands only by colonial wading birds and seabirds for only one field season. Before any active general management plans can be effected, more data must be made available to determine patterns of use of these islands by these and other species and under varying conditions. These islands are used by many bird species and other vertebrate and invertebrate groups, not only for breeding but for feeding, loafing, and roosting. The year-round use patterns by wildlife have not been studied and are essential knowledge for intelligent land use planning. Much remains to be learned about wildlife use of dredged material sites in New Jersey and an ongoing research program should be part of any management plan.

Colonial wading bird/seabird management recommendations

164. The following management recommendations are concerned with the needs of colonial wading bird and seabird species in New Jersey and are not necessairly listed in order of importance. They are:

a. Colonial waterbird survey. An annual survey of dredged material sites should be made to locate nesting colony sites before any dredged material disposal operation. In New Jersey, the optimal time for this survey would be in mid-May, when wading bird and gull nesting is well underway and terns are on their nest sites.

b. Deposition on colony sites. Dredged material disposal on colony sites during the nesting season is unlawful and in violation of numerous Federal and State wildlife protection regulations. If deposition must be made on a known colony site because no other alternative is available, or wildlife management practices require it, it should be done before or after the nesting season.

c. Habitat survey. A habitat survey should be made of the dredged material islands along the New Jersey Intracoastal Waterway on an annual or biennial basis to determine the proportions of habitat types available to all colonial species. Locations of bare sand habitat are needed most to manage early and early-mid seral stages. Islands with late seral stage vegetation suitable for wading bird colonies should be noted and managed for use by these species. Once needs are determined, deposition of uncontaminated sand/shell/gravel dredged material should be made at the proper time and in a location that is attractive to the desired species. Care should be taken that this does not disrupt a late seral stage site in use by wading birds.

d. Maintain bare sand habitat. Bare sand/shell/gravel is in short supply in New Jersey and the two state endangered colonial species, least terns and black skimmers, both require this type of substrate for nesting. Present or previously used nest sites should be maintained at a very early seral stage for these species. Defoliation and disking or controlled burning procedures should be investigated on sites currently in use that are becoming too densely vegetated.

e. Alternative colony sites. Because of predation or human disturbance, it is important that colonial nesting species have alternate nest sites available to them (e.g. Pork Island heronry was burned out in May 1977) if they should have to desert a colony site early in the season. At the Stingaree Point colony red fox predation in early May 1977 disrupted a large mixed-species heronry, causing a number of birds to desert their nests. Nearby colonies at Shaw Cutoff and Shaw Island were available and did increase in numbers as the Stingaree Point colony decreased. Maintenance of alternative sites with suitable habitat in the same general location will allow not only the reduction of disturbance pressures but also facilitate a program of rotational management at each site.

f. Rotational management. The placement of several dredged material islands in the same general location will allow a planned pattern of disposal and seral stage development, with disposal at the same site at planned intervals coinciding with the need for bare sand or early, mid and late seral stage management. Late seral stage development and management would have to have at least 10 to 20 year intervals between depositions on alternating islands to provide required vegetation for wading birds. Shorter term management programs could be used for terns and skimmers. Forster's terns and laughing gulls would be unaffected unless disposal occurred on salt marsh nesting sites. Management programs to provide needed sand habitat to common terns, unsuitable for gulls, would be desirable since gull species prey on eggs and young of other colonial species.

g. Wading bird management considerations. Wading birds use dredged material islands more than other colonial species in New Jersey. Their preference for shrub, shrub-forest and reed-shrub communities means that long-term management programs are needed. Currently, there seem to be adequate suitable islands available to them for colony sites. Dredged material disposal would disrupt or destroy the more advanced upland vegetation that herons require. Only a few of their present colony sites (40, A80a) are diked. These sites are on comparatively large-sized islands with low, overgrown dikes, and the actual colonies are well away from the dikes. It is recommended that islands supporting heronries be left undisturbed because of the 10 to 20 year time period required to attain the proper plant communities required by these birds. But, if use of these sites is unavoidable, and diking must be used, it is recommended that compartmentalized diking with disposal in only a portion of the island removed from the heronry be done in order to preserve the heronry site. Any activities on the island should be during the non-nesting season. Yearly wading bird movements between nesting colony sites should be noted. The presence of herons at certain previously used sites in May 1977 and their movement by June, combined with other historical data (Appendix A), indicate that waiting periods of 2 to 3 years is needed before disposal at a colony site resumes.

h. Proportional representation. Working in cooperation with State and Federal ornithologists, various seral stages on dredged material sites should be maintained along the New Jersey Intracoastal Waterway in various proportions. The present distribution of colonial species at dredged material sites indicates that different deposit configurations attract different species. Low elevation broadcasting of dredged material could be used to provide salt marsh nest sites for laughing gulls, gull-billed terns, and possibly Forster's terns. High, domed, circular islands are all but lacking in New Jersey (A12 is the only such site) but would attract least terns, common terns, and black skimmers for many years because of the longer time period required for them to become densely vegetated and unsuitable to terns and skimmers. Lower domed, large islands which become vegetated more rapidly could be placed in desirable locations and allowed to develop late seral stage vegetation naturally or by planting maritime shrubs for wading birds or managed to maintain early and mid seral stages of vegetation utilized by common terns, black skimmers, and least terns.

i. Diking. The desirability of diking has not been investigated in New Jersey. The fact that such islands do not support a major proportion of the colonial bird population in New Jersey despite their bare sand availability would indicate that they are in some way undesirable. However, the presence of least terns on these sites and heronries on several older diked sites necessitates further investigation of these sites before supportable conclusions can be drawn.

j. Protection on dredged material islands. The paucity of undeveloped, undisturbed, and uncrowded bare sand in New Jersey, coupled with recreational users such as boaters, swimmers, and picnickers attracted to dredged material island beaches is a definite problem. They walk through seabird colonies, bring their dogs, and generally disrupt nesting birds. The

State of New Jersey has instituted a posting program for least tern colonies which may be helpful in minimizing human disturbance at these sites. This program should be expanded to include all colonial bird colonies and all dredged material island colonies especially. Buckley and Buckley (1976) provide numerous means of dealing with protection problems.

165. The preceding list of management recommendations is not meant to provide a complete management program for dredged material islands or colonial nesting seabirds and wading birds. It is hoped that these recommendations can be a starting point for further investigation by the Corps of Engineers in cooperation with the many groups and agencies that are concerned with the management, preservation and protection of our wildlife resources. Dredged material islands can provide much needed habitat for many species, as this study has shown, and their enlightened management and use of wildlife purposes should be encouraged.

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APPENDIX A: A HISTORICAL PERSPECTIVE

(on microfiche in pocket of inside back cover)

APPENDIX B: VEGETATION ANALYSIS

(on microfiche in pocket of inside back cover)

APPENDIX C: MISCELLANEOUS MAPS AND FIGURES

Table C1

New Jersey Intracoastal Waterway Dredged Material Sites

Number	Name	Latitude	Longitude	Hectares	Age	Reference
A12 North*	Pelican Island North	39°57'	74°05'	6.4 **	pre 1969[3]	2
A12*	Pelican Island	39°57'	74°05'	2.6 **	pre 1969[3]	2
A35*	East Carvel Island	39°41'	74°10'	2.5 **	pre 1969[3]	3
X18	Cedar Bonnet	39°39'	74°12'	2.04	1977	3
40	Flat Island	39°38'	74°12'	23.4	1965	1
A40	High Island	39°37'	74°12'	6.4	n.a.	2
A43a*	Ham Island	39°36'	74°13'	8.1	n.a.	2
A43b	Marshelder Island East	39°35'	74°14'	27.9	n.a.	1
	Marshelder Island West	39°35'	74°14'	27.9	n.a.	1
45A*	Parker Island	39°34'	74°15'	5.6	1976	1
45B*	-----	39°34'	74°15'	1.6	1976	1
X47	Barrel Island	39°34'	74°17'	20.7	1963	1
X27*	Goosebar Sedge	39°32'	74°17'	13.2	pre 1969	3

(Continued)

* study island

** estimated size

1 U.S. Army Corps of Engineers, Philadelphia District

2 Nordstrom et al. 1974

3. Ocean County Mosquito Commission

4. total island size, (Cape May County Records); study site - 1.2 ha

5 New Jersey Department of Environmental Protection

6 bird banding data, U.S. Fish and Wildlife Service

n.a. = not available

Table C1 (Continued)

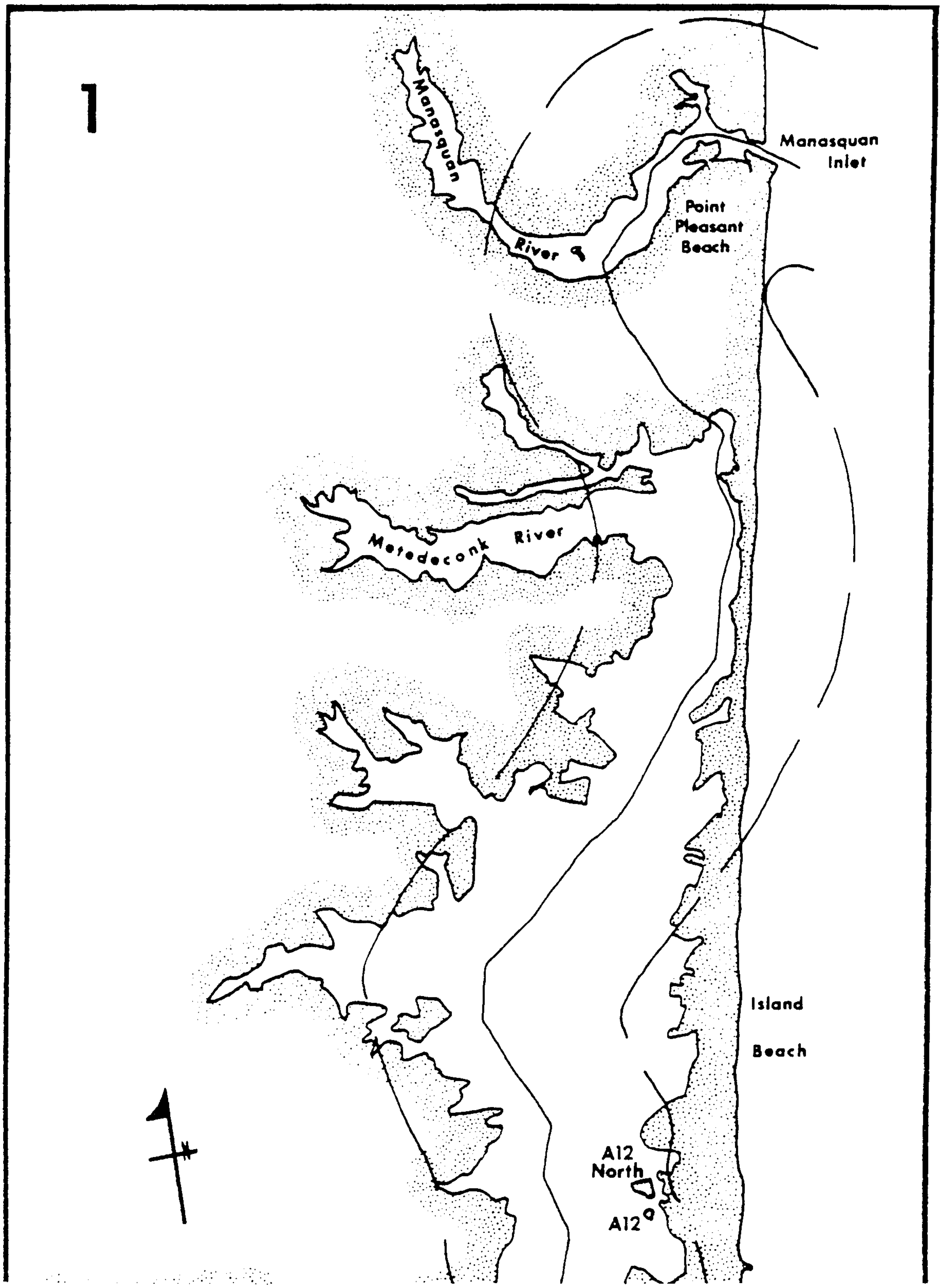
Number	Name	Latitude	Longitude	Hectares	Age	Reference
51B*	Shooting Thorofare	39°31'	74°18'	17.0	1965	1
58	Shad Island	39°28'	74°24'	11.3	1977	1
A59a*	Perch Cove Pt./Big Shad	39°28'	74°24'	2.4	1968	1
60	Black Point	39°26'	74°24'	11.3	1976	1
61	Oyster Thoro Marsh	39°26'	74°24'	71.5	1967	1
A61b	Islajo	39°25'	74°25'	8.8	pre 1959	6
A61c*	Little Heron Island	39°24'	74°26'	5.5	pre 1959	6
65	---	39°33'	74°25'	6.8	1969	1
77	Risley Channel	39°20'	74°33'	109.1	1964	1
78A	Broad Thorofare	39°19'	74°34'	109.9	1976	1
78B*	Broad Thorofare	39°19'	74°34'	50.9	1969	1
A80a	Cowpens Island	39°17'	74°35'	49.3	n.a.	5
A80b	Shooting Island	39°16'	74°36'	29.9	n.a.	2
82	Beach Thoro	39°16'	74°38'	5.7	1969	1
82A	----	39°16'	74°36'	8.1	1974	1
83	Crook Horn Creek	39°16'	74°38'	12.5	1964	1
84	Crook Horn Creek	39°14'	74°38'	11.0	1976	1
84A	Crook Horn Creek	39°14'	74°38'	3.4	1976	1
85A	Beach Creek	39°14'	74°39'	17.0	1976	1
85dmi*	Weakfish Creek	39°13'	74°39'	3.1	1966	1
85B	Middle Thoro	39°13'	74°39'	13.6	1966	1
85 South*	Middle Thoro	39°15'	74°39'	13.6	1966	1

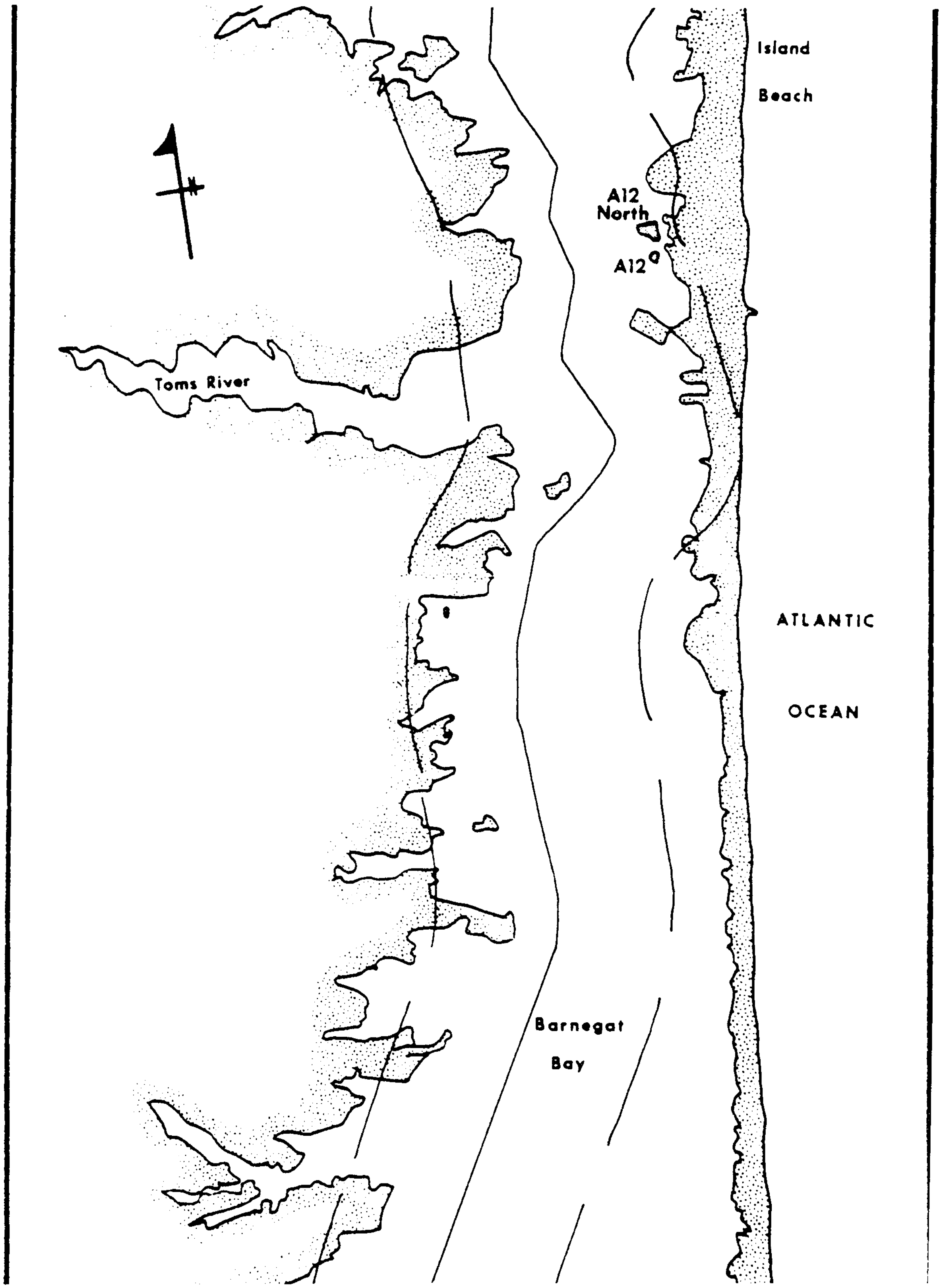
(Continued)

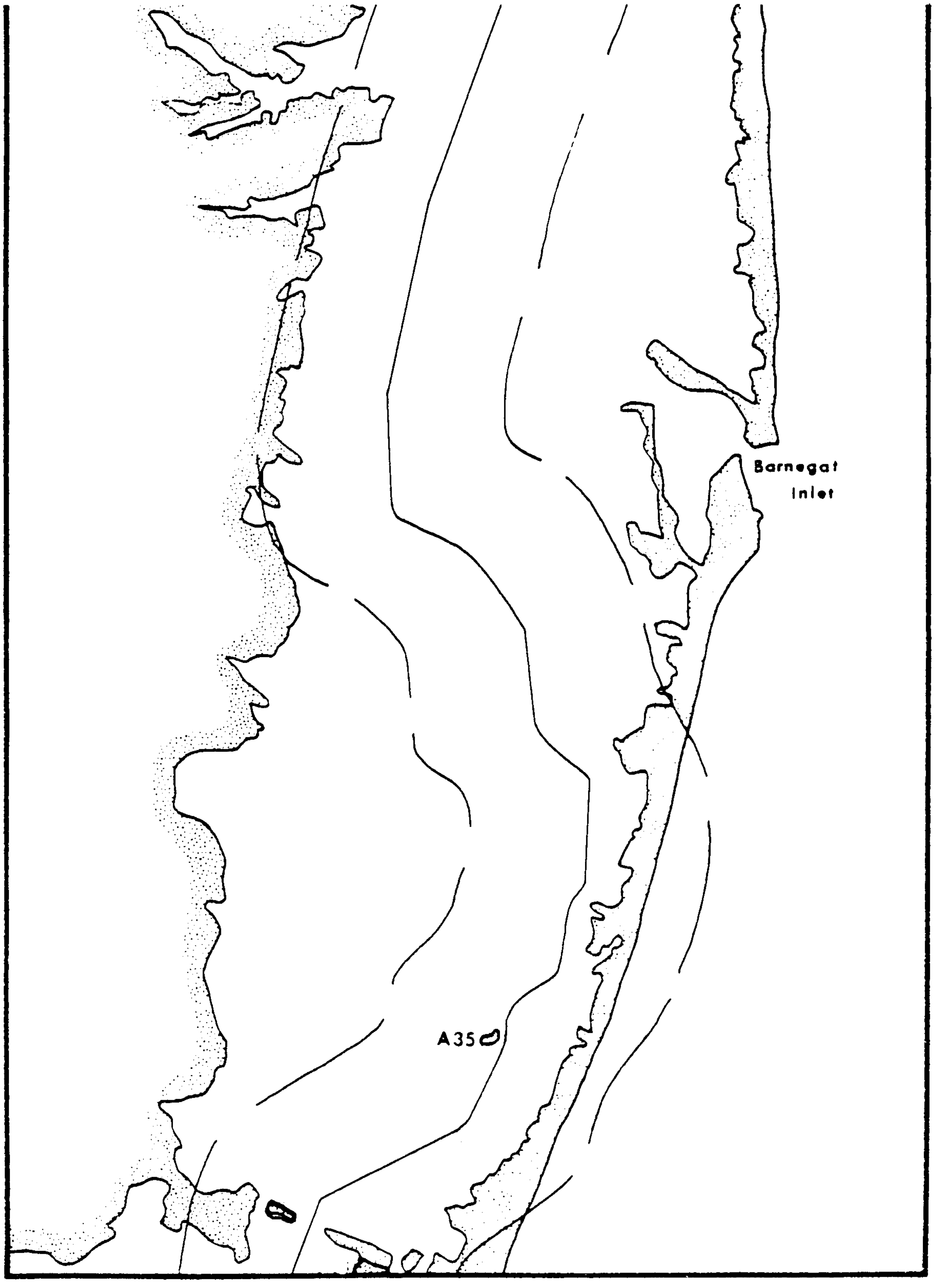
Table C1 (Concluded)

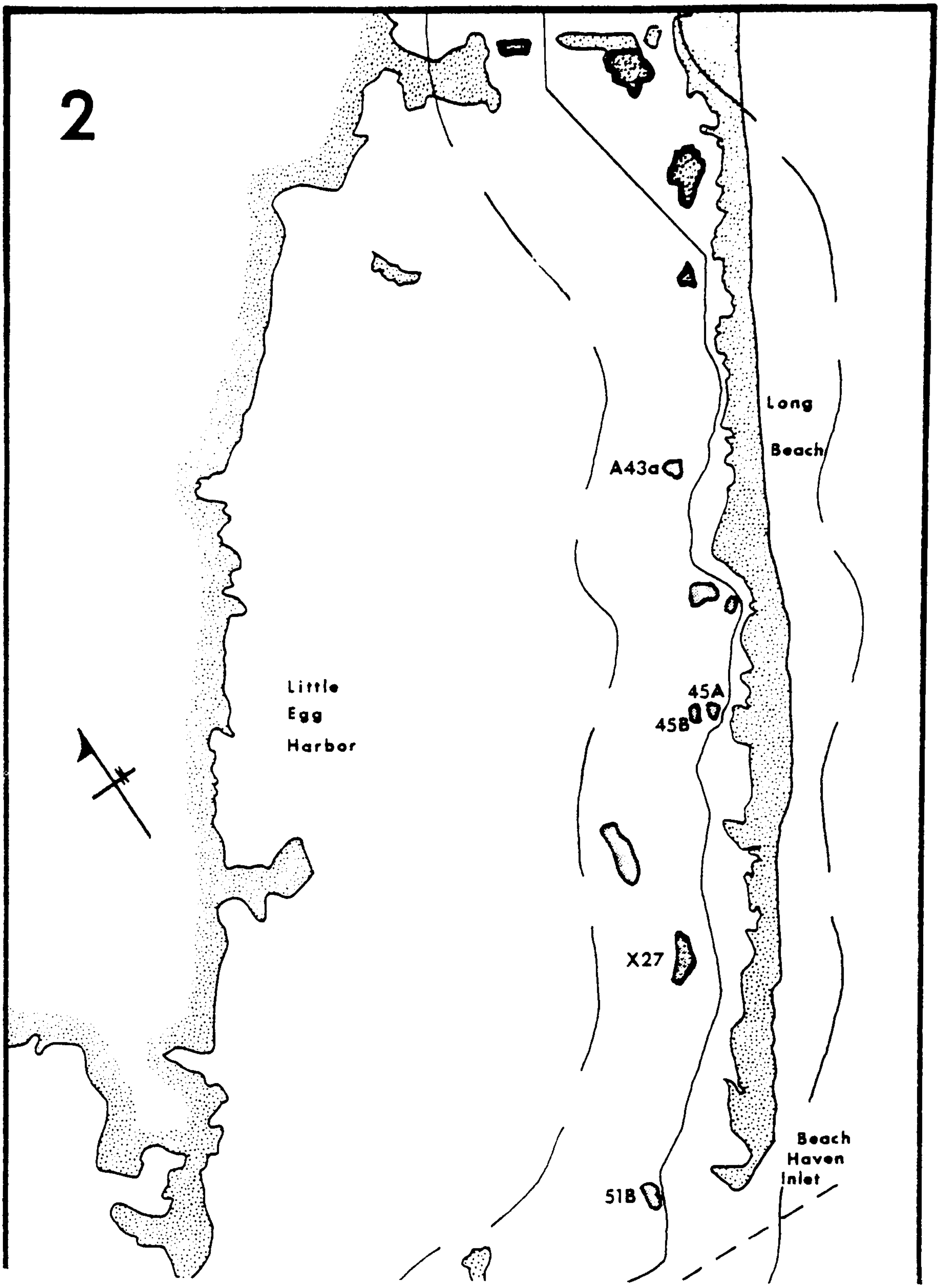
Number	Name	Latitude	Longitude	Hectares	Age	Reference
85C*	Devils Thoro	39°14'	74°39'	13.6	1976	1
86	Ben Hands Thoro	39°12'	74°40'	34.1	1968	1
90	Ludlum Bay	39°10'	74°42'	20.4	1977	1
97A	----	39°06'	74°46'	27.3	1968	1
97B	Great Sound	39°06'	74°46'	20.4	1968	1
98A*	Sturgeon Island	39°05'	74°46'	5.9	1968	1
98B North*	Gull Island North	39°05'	74°46'	14.5	1968	1
98B South*	Gull Island South	39°05'	74°46'	14.5	1968	1
103*	Nummy Island	39°02'	74°48'	129.3	1975	1
106	North Wildwood Road	39°02'	74°49'	0.8	1963	1
108A	Grassy Sound Channel	39°00'	74°50'	7.7	1974	1
108B*	----	39°00'	74°50'	2.8	1965	1
108C	----	38°59'	74°50'	6.8	n.a.	1
109*	Shaw Island	38°59'	74°51'	32.7	1965	1
109 South*	------	38°59'	74°51'	2.0	1965?	2

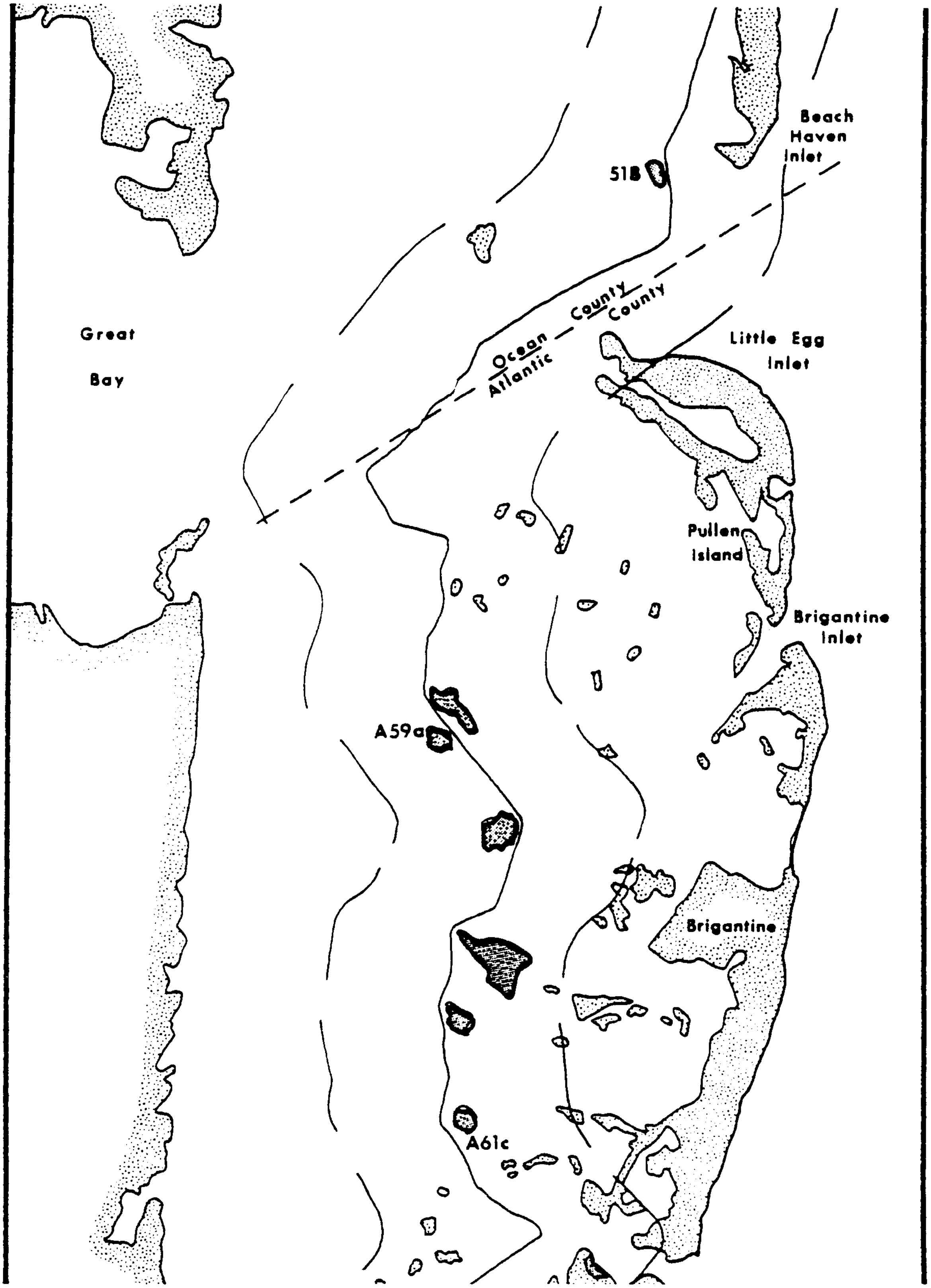
Figure C1. Locations of dredged material study islands on NOAA navigation charts for the New Jersey coast (three different charts). Chart 1: Manasquan Inlet south to Barnegat Inlet. Chart 2: Long Beach south to Ocean City. Chart 3: Great Egg Harbor south to Cape May.

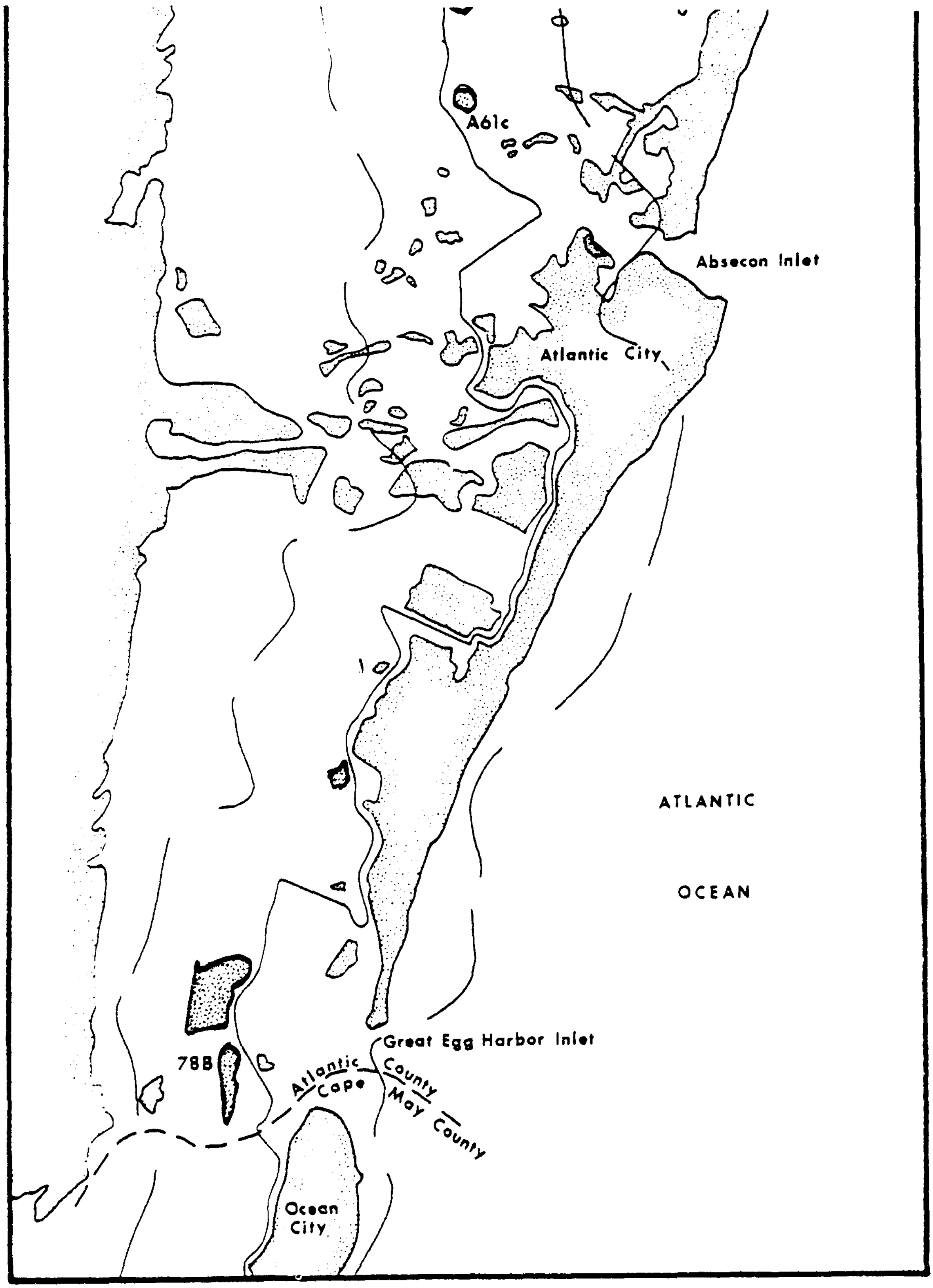

1
Manasquan
River
Manasquan
Inlet
Point
Pleasant
Beach
Metedeconk River
Island
Beach
A12
North
A12

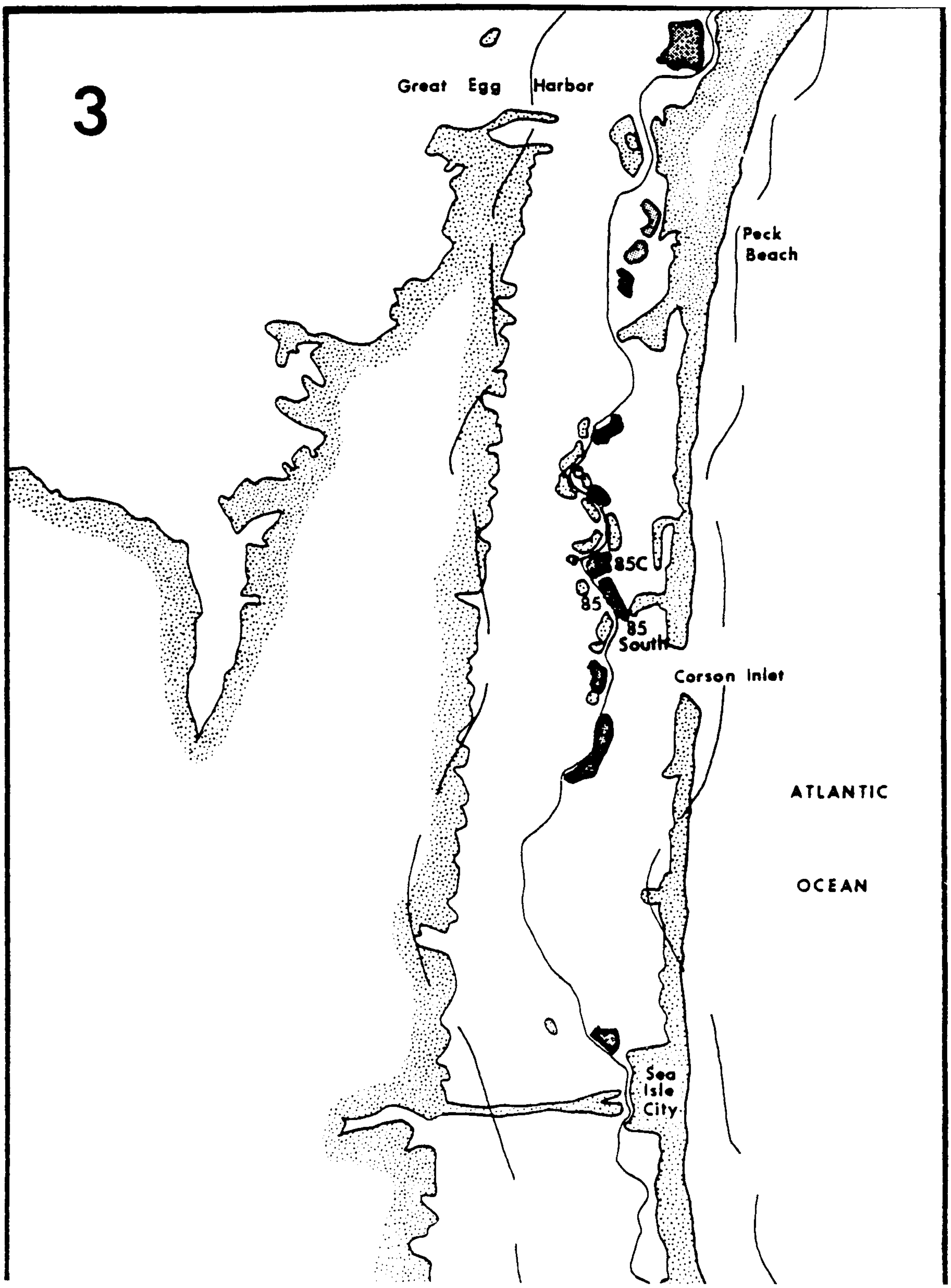

Island
Beach
N
A12
North
A12
Toms River
ATLANTIC
OCEAN
Barnegat
Bay

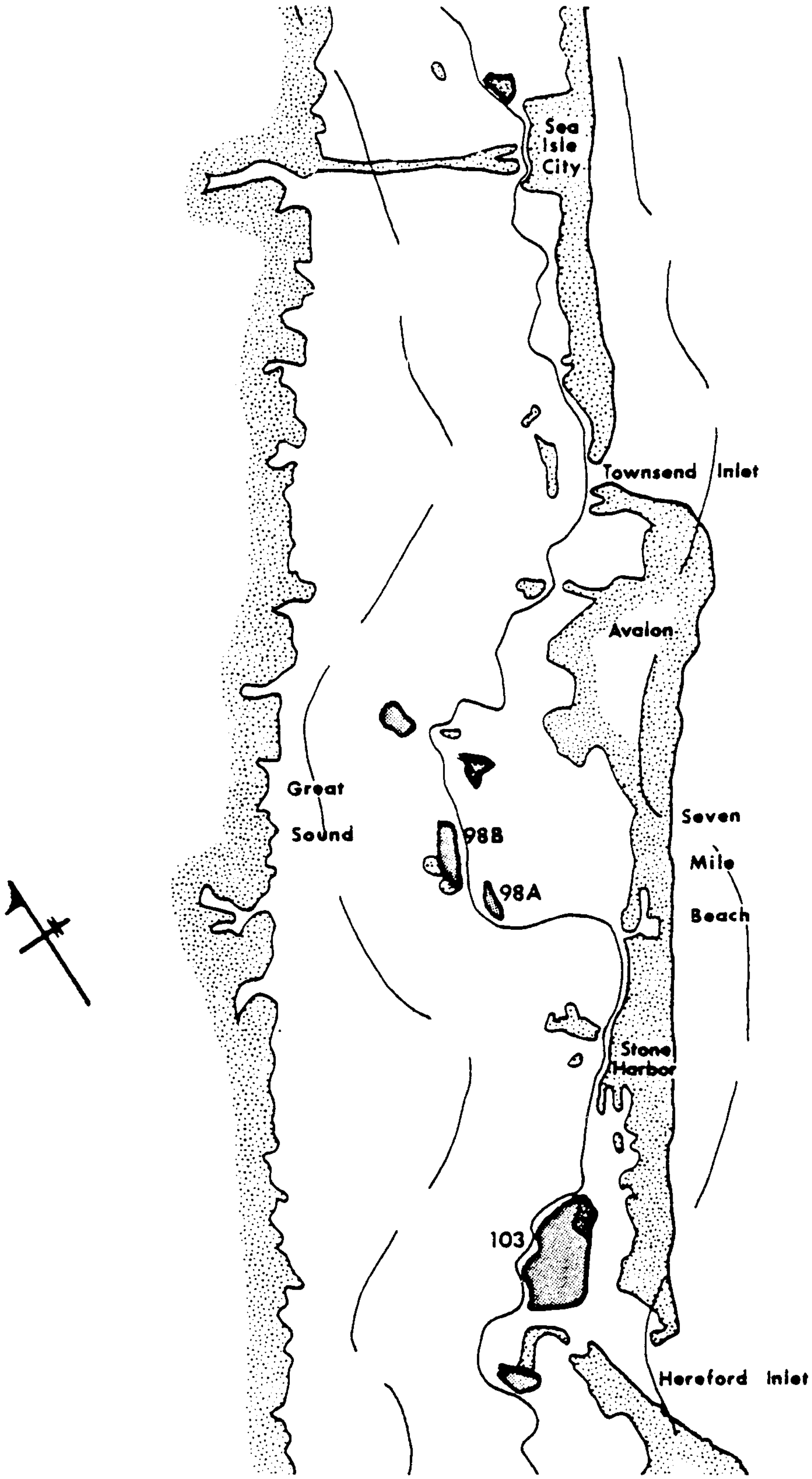

Barnegat
Inlet
A35


2
Long
Beach
A43a
Little
Egg
Harbor
45A
45B
X27
Beach
Haven
Inlet
51B


Beach
Haven
Inlet
51B
Great
Bay
Ocean
County
Atlantic
County
Little Egg
Inlet
Pullen
Island
Brigantine
Inlet
A59a
Brigantine
A61c


A61c
Absecon Inlet
Atlantic City
ATLANTIC
OCEAN
Great Egg Harbor Inlet
78B
Atlantic County
Cape May County
Ocean City


3
Great Egg Harbor
Peck Beach
85C
85
85 South
Corson Inlet
ATLANTIC
OCEAN
Sea Isle City


Sea
Isle
City
Townsend Inlet
Avalon
Great
Sound
98B
98A
Seven
Mile
Beach
Stone
Harbor
103
Hereford Inlet

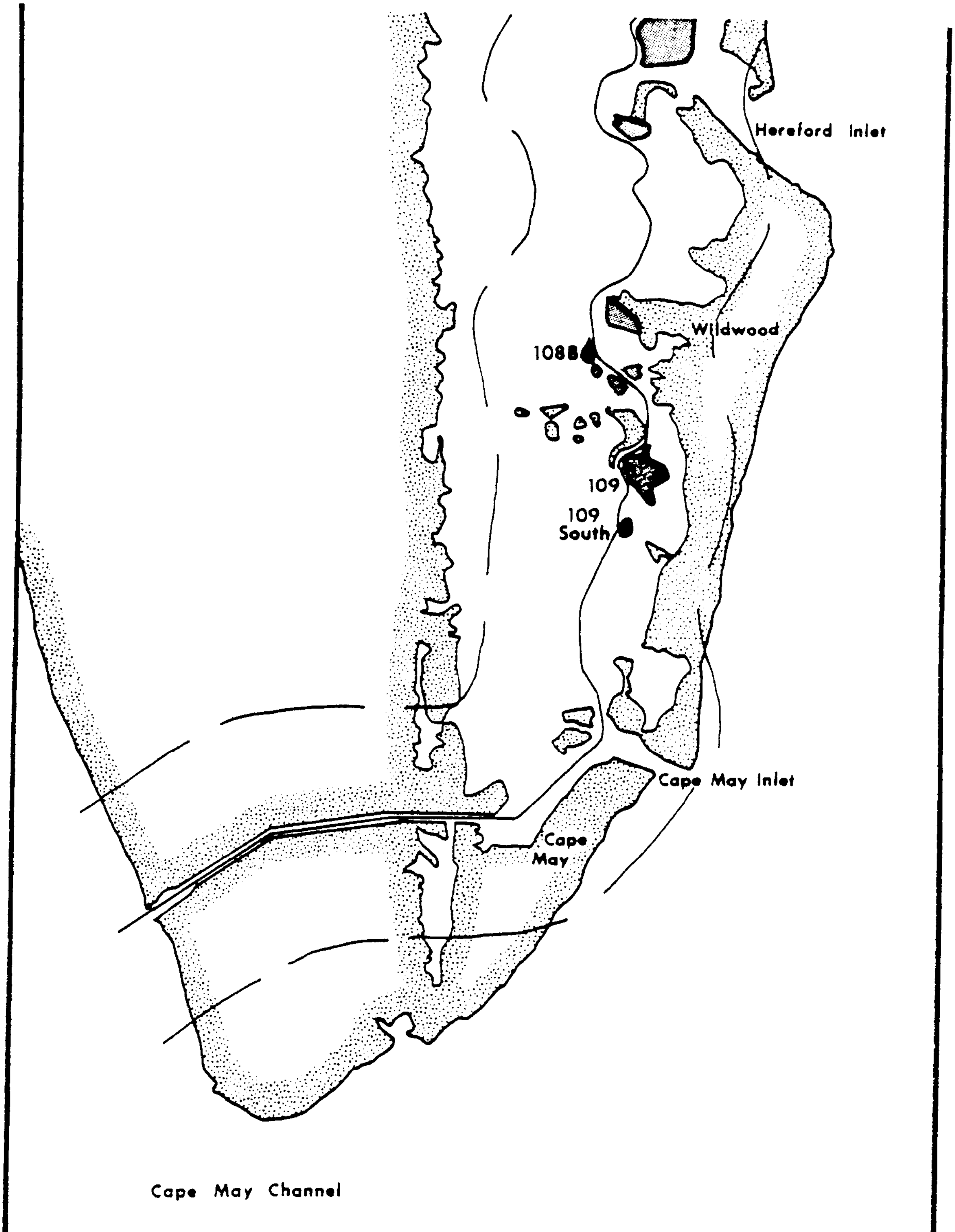
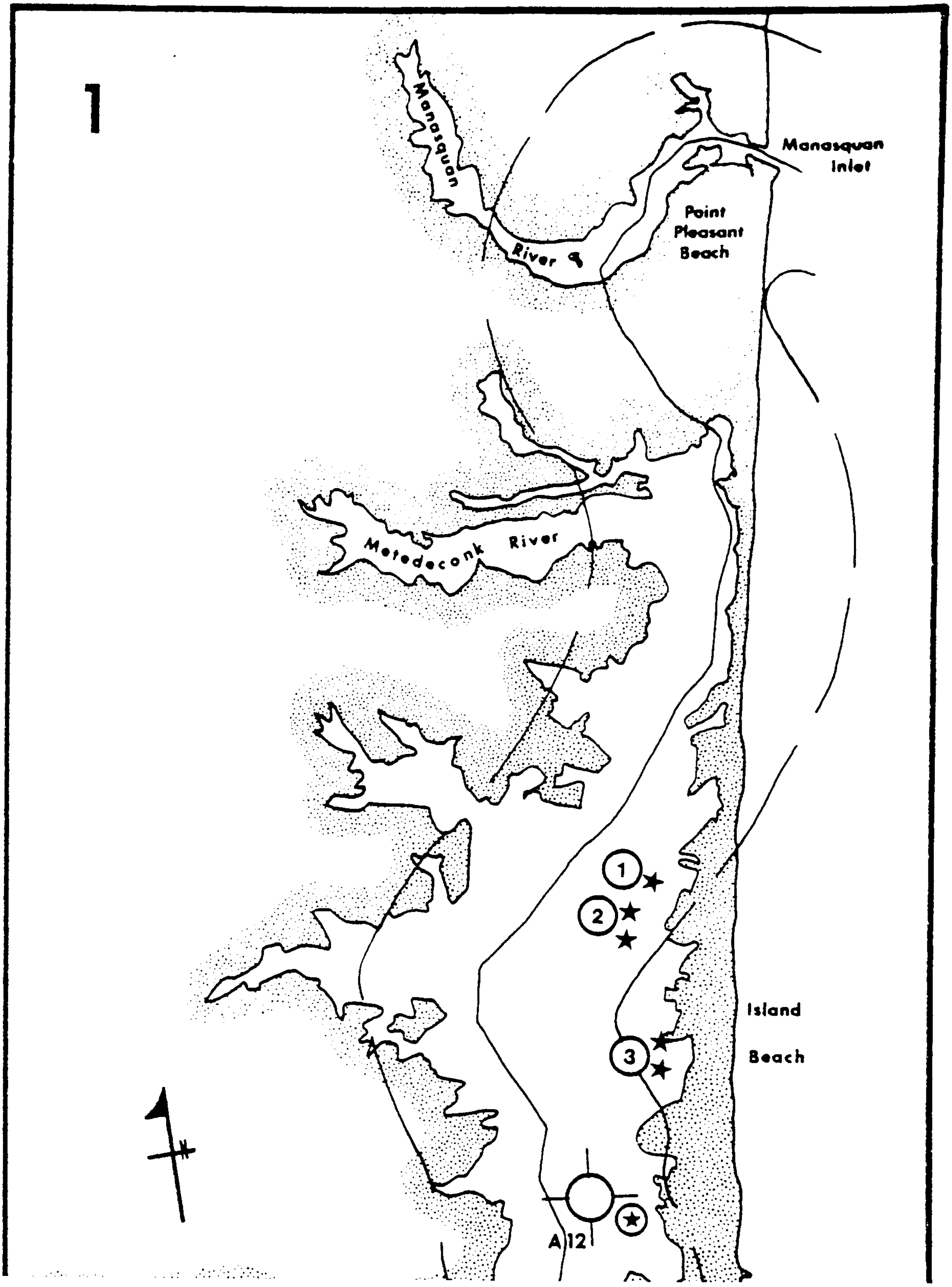
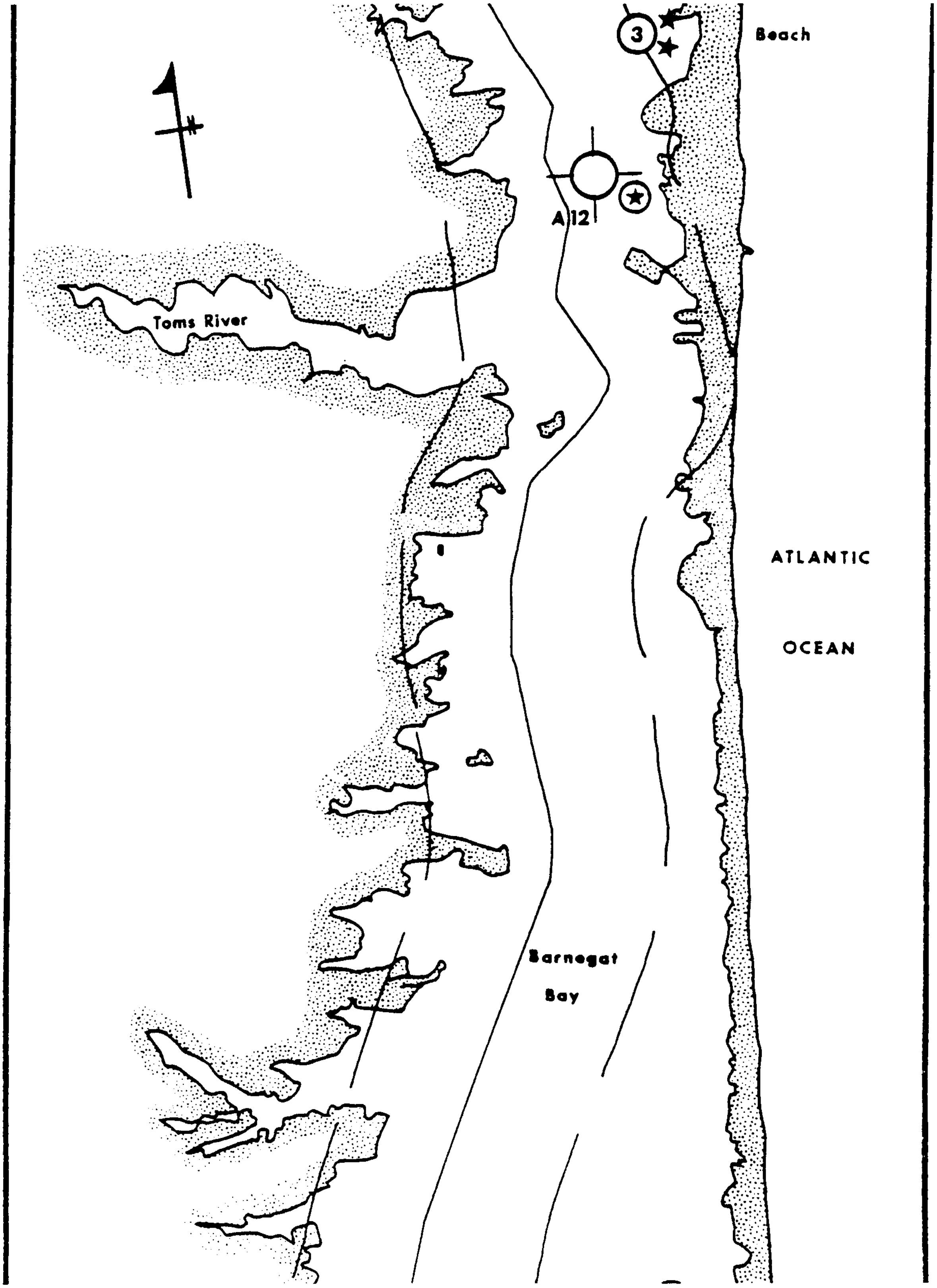

Hereford Inlet
Wildwood
108B
109
109
South
Cape May Inlet
Cape
May
Cape May Channel

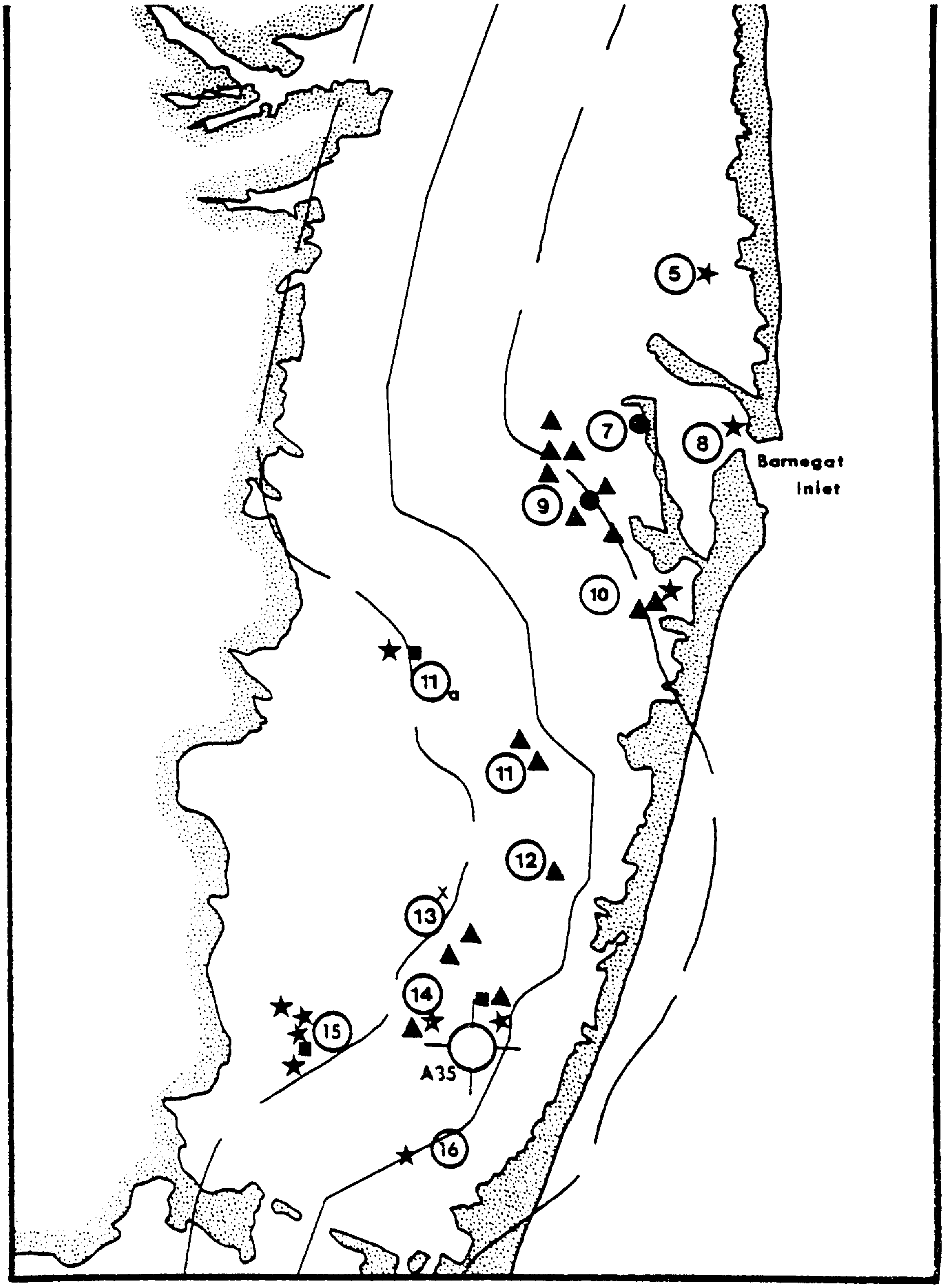
Figure C2. Waterbird colonies located along the New Jersey Intercoastal Waterway in 1977, shown on three NOAA navigation charts for the New Jersey coast.

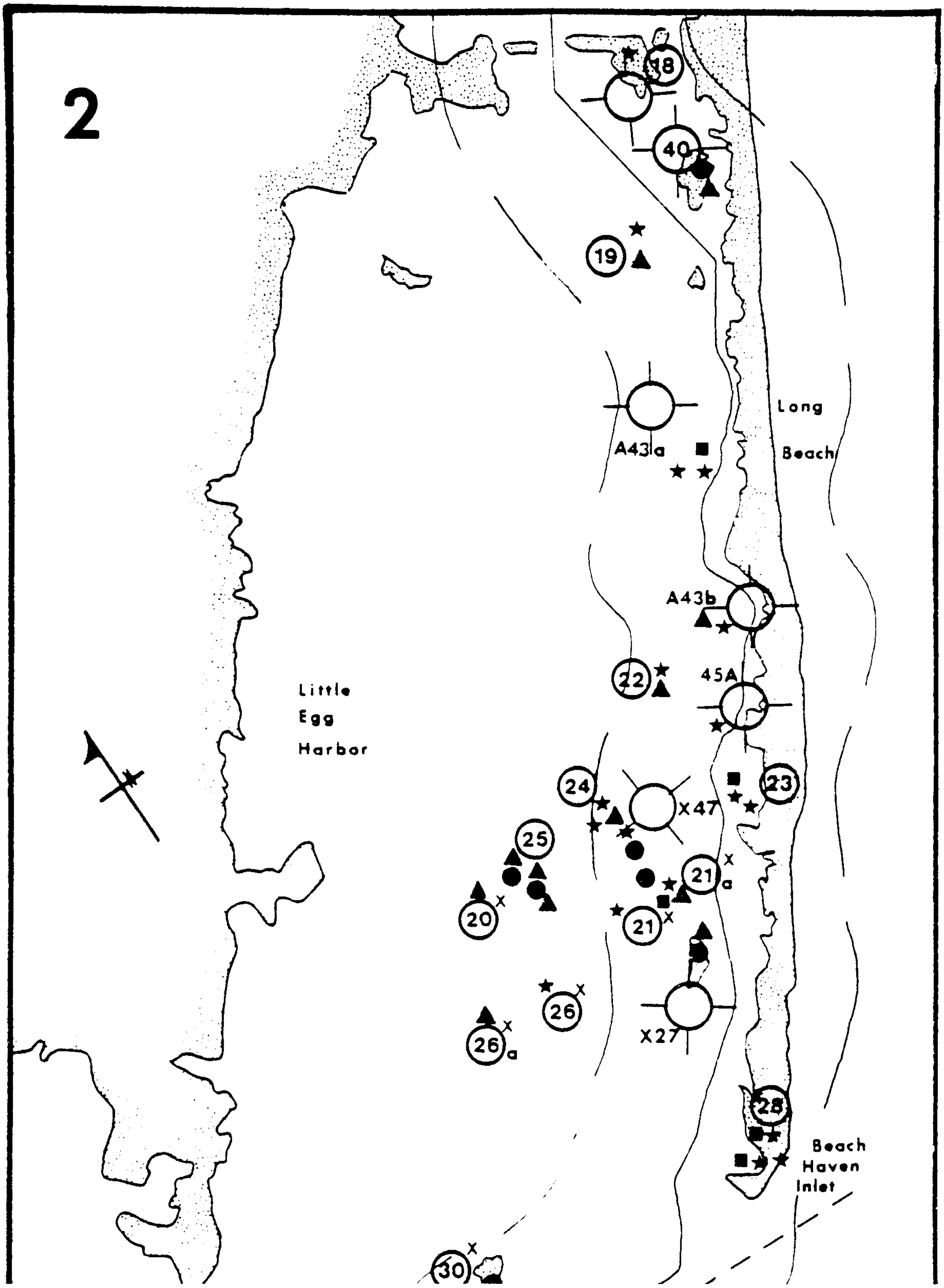
<u>Key:</u>

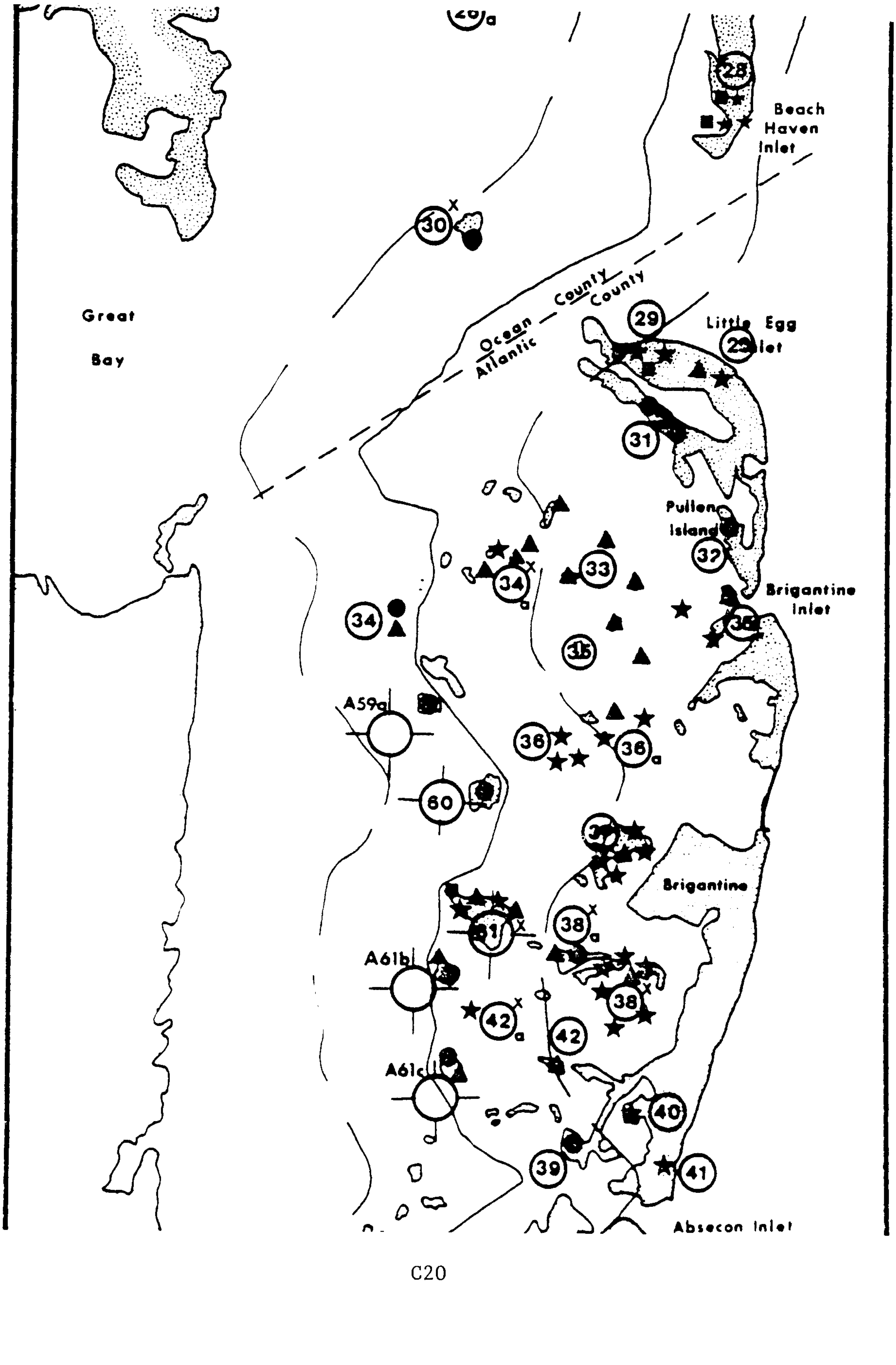
Heronry	●
Gull colony	▲
Tern colony	★
Black skimmers	■
Colony site locations	#
New colony sites	# *
Dredged material study sites	¤

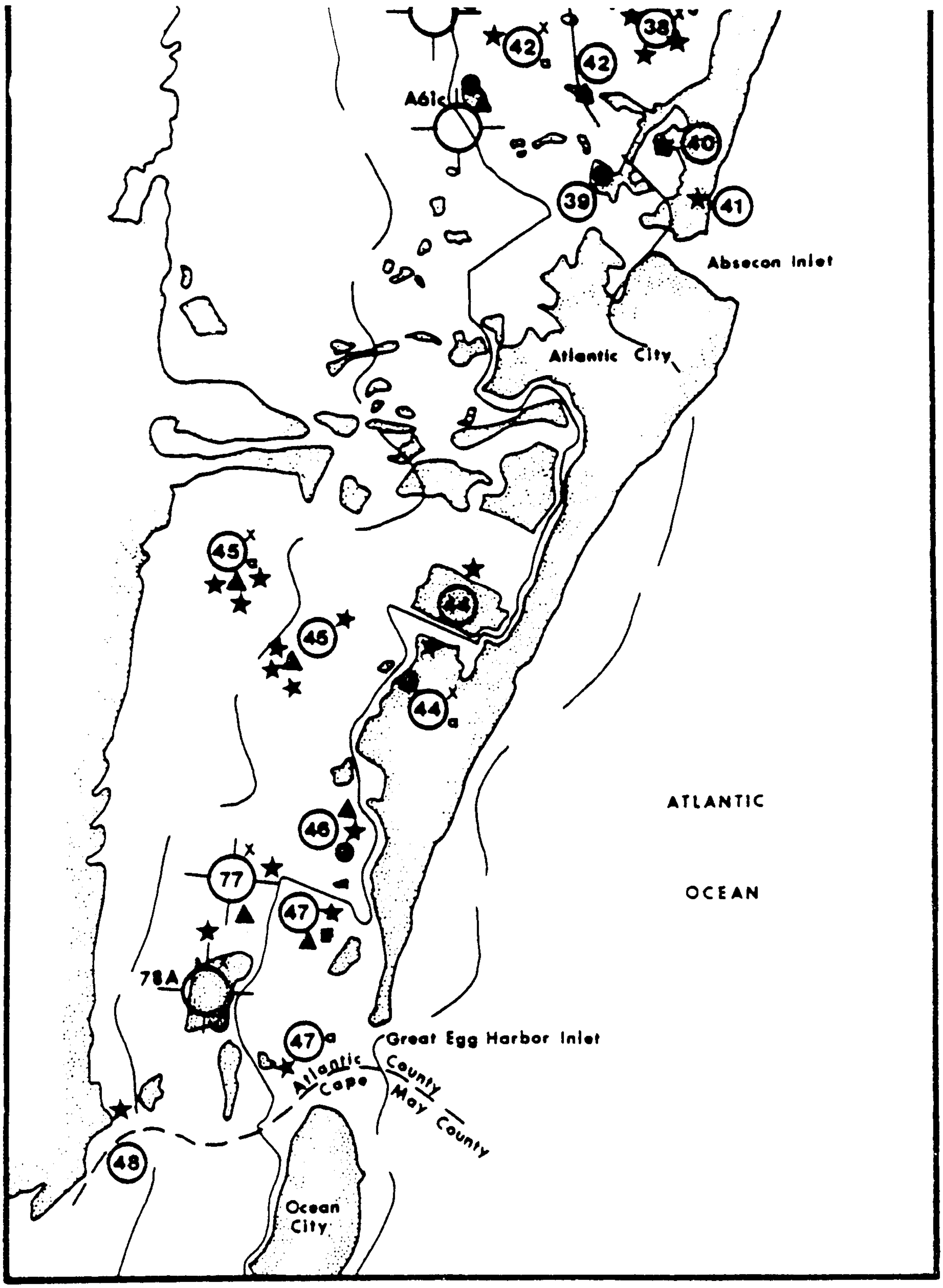

1
Manasquan
River
Manasquan
Inlet
Point
Pleasant
Beach
Metedeconk
River
1
2
3
Island
Beach
A 12

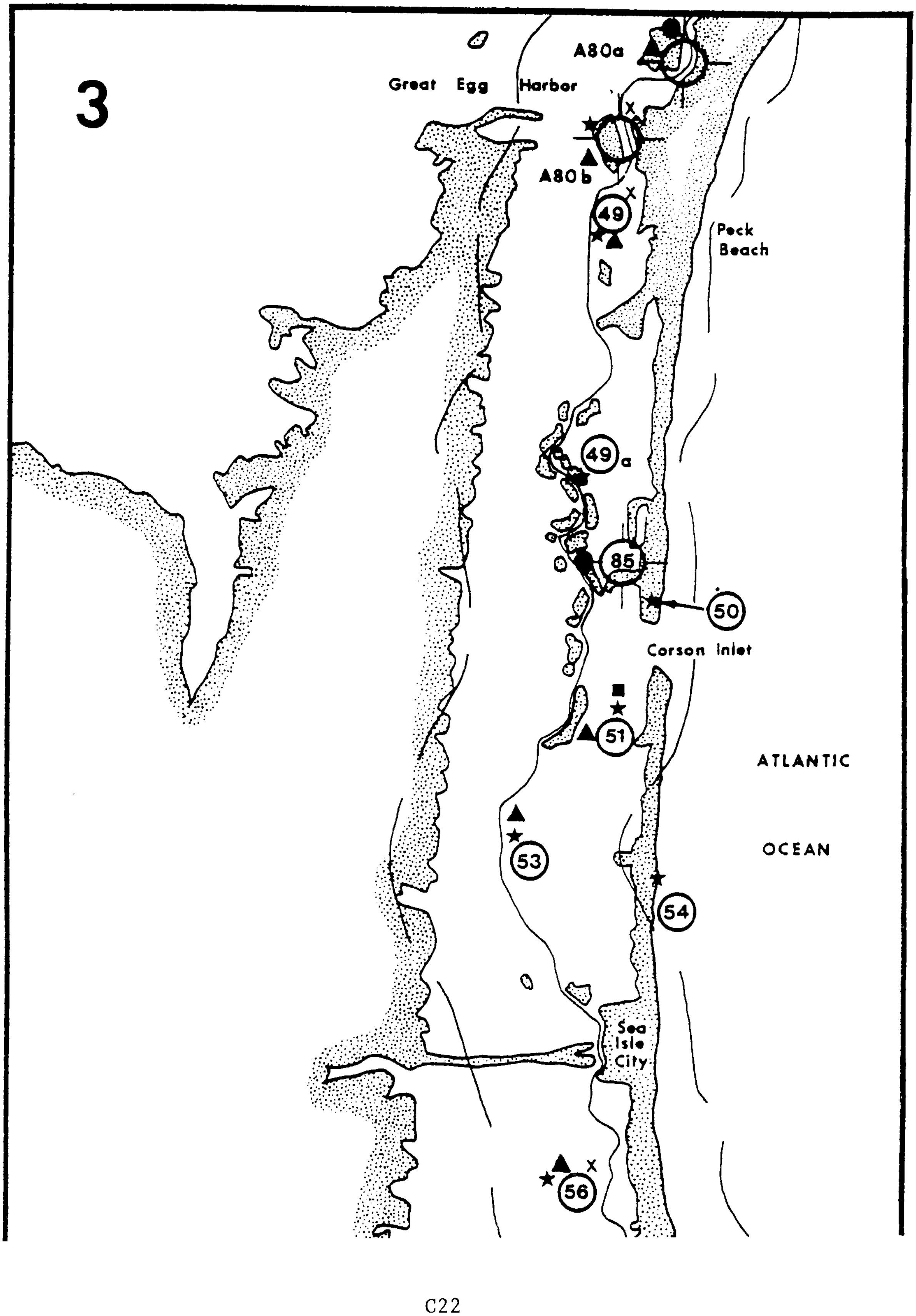

Beach
3
A 12
Toms River
ATLANTIC
OCEAN
Barnegat
Bay


5
7
8
Barnegat
Inlet
9
10
11a
11
12
13
14
15
A35
16

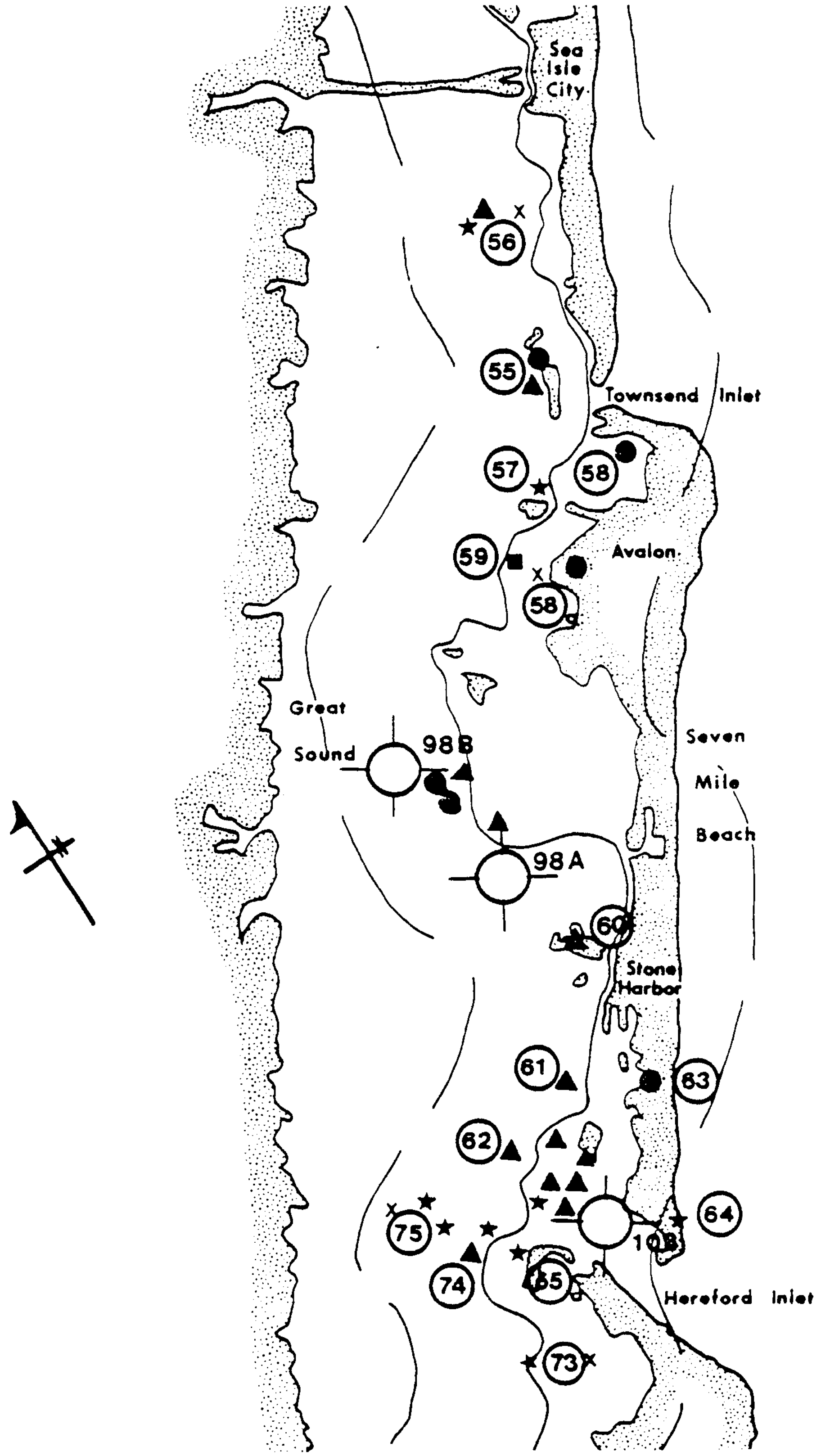

2
18
40
19
Long
Beach
A43a
A43b
22
45A
Little
Egg
Harbor
24
X47
23
25
21
a
20
21
26
26
a
X27
28
Beach
Haven
Inlet
30

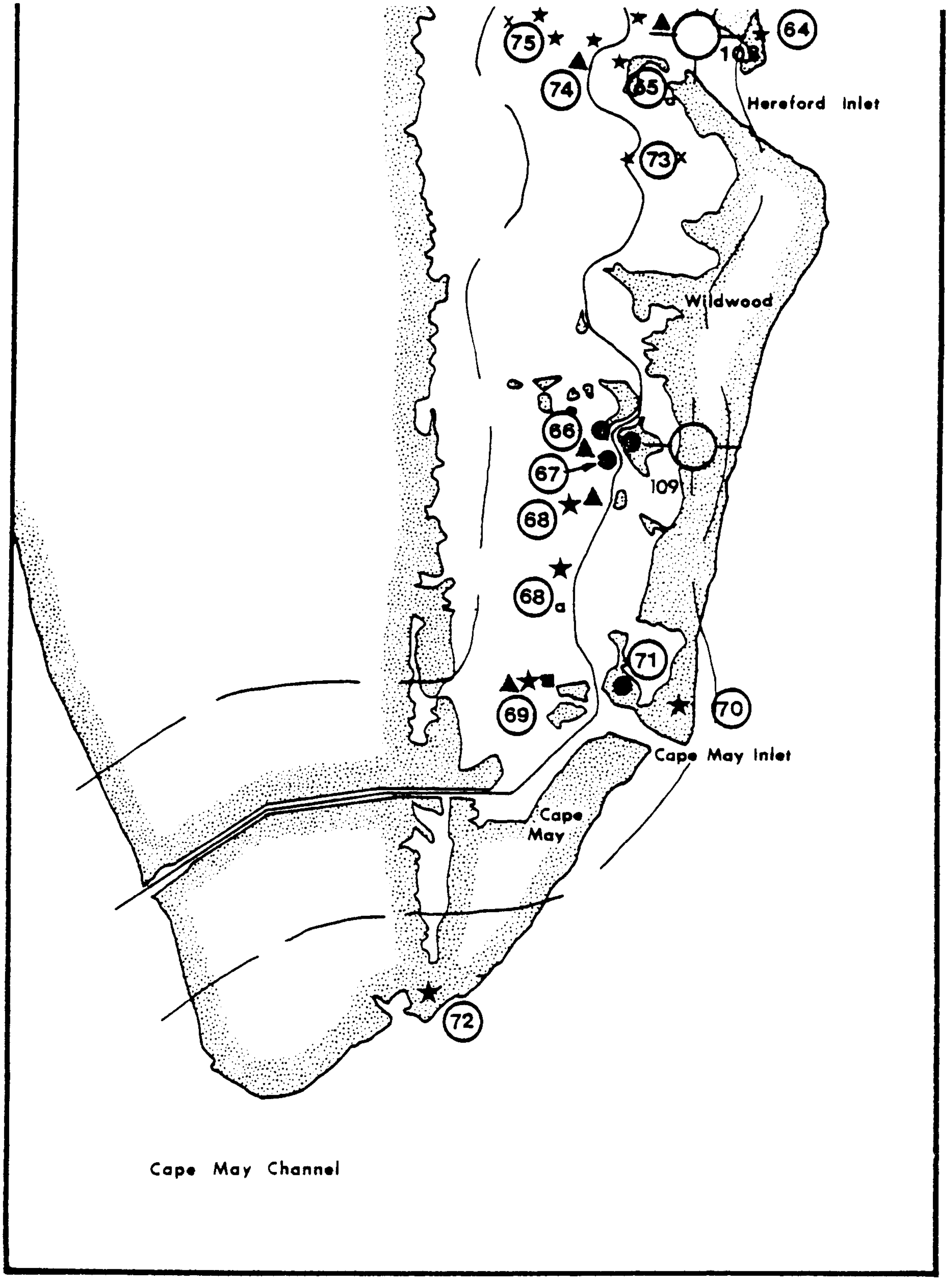

Beach
Haven
Inlet
30
Great
Bay
Ocean
County
Atlantic
County
29
Little Egg
Inlet
31
Pullen
Island
32
33
34
34
35
Brigantine
Inlet
A59a
36
36
60
Brigantine
38
38
A61b
42
42
A61c
40
39
41
Absecon Inlet


38
42
42
A61c
40
39
41
Absecon Inlet
Atlantic City
45
45
44
44
ATLANTIC
OCEAN
46
77
47
78A
47
Great Egg Harbor Inlet
Atlantic County
Cape May County
48
Ocean City



3
Great Egg Harbor
A80a
A80b
49
Peck Beach
49a
85
50
Corson Inlet
51
ATLANTIC
OCEAN
53
54
Sea Isle City
56


Sea
Isle
City
56
55
Townsend Inlet
57
58
59
Avalon
58
Great
Sound
98B
Seven
Mile
Beach
98A
60
Stone
Harbor
61
63
62
64
75
10B
74
65
Hereford Inlet
73


75
74
65
64
108
Hereford Inlet
73
Wildwood
66
67
109
68
68a
71
69
70
Cape May Inlet
Cape May
72
Cape May Channel

APPENDIX D:

PHOTOGRAPHS OF THE 21 STUDY ISLANDS

Figure D1. Aerial view of Study Island A12

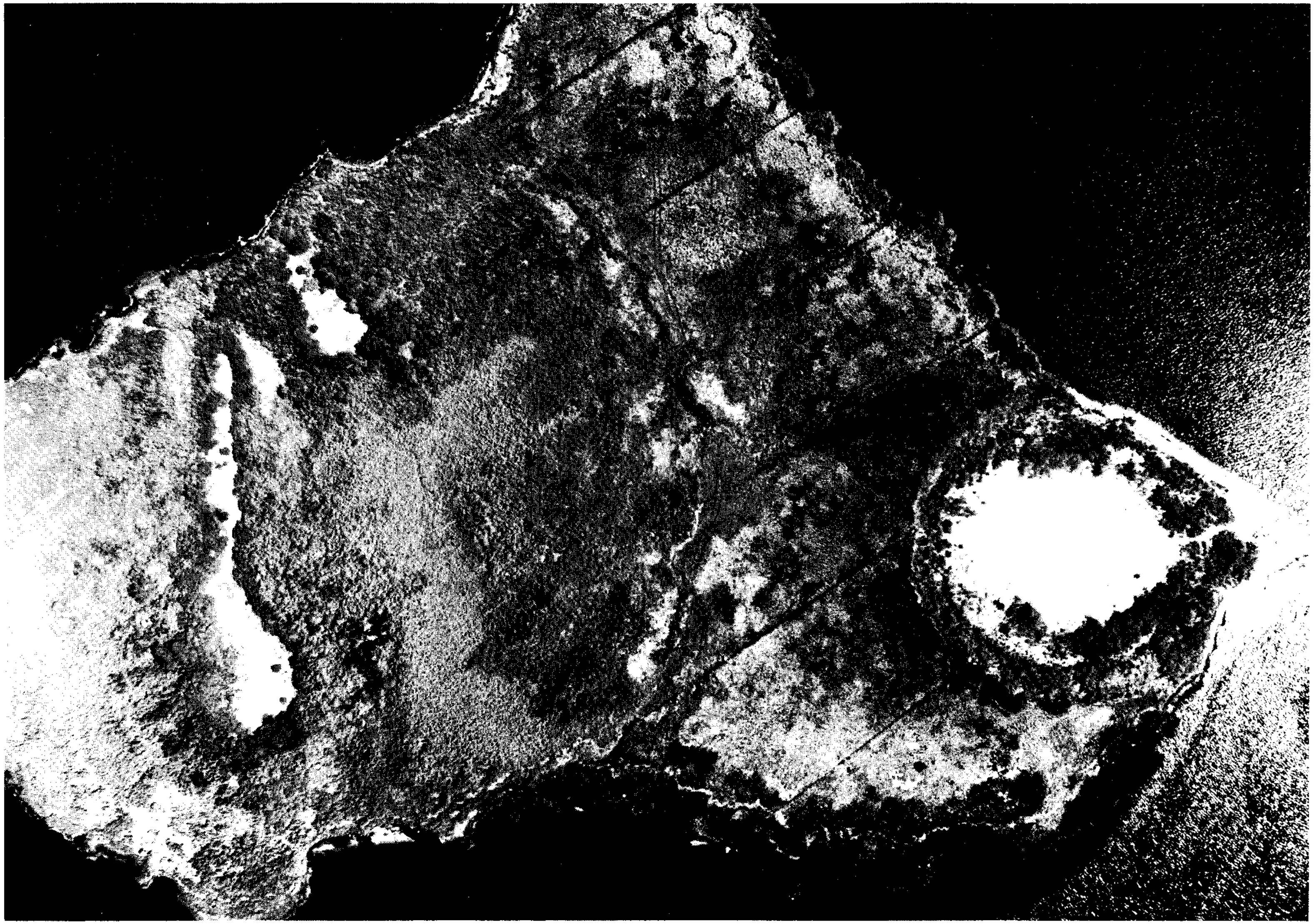


Figure D2. Aerial view of Study Island A12 North

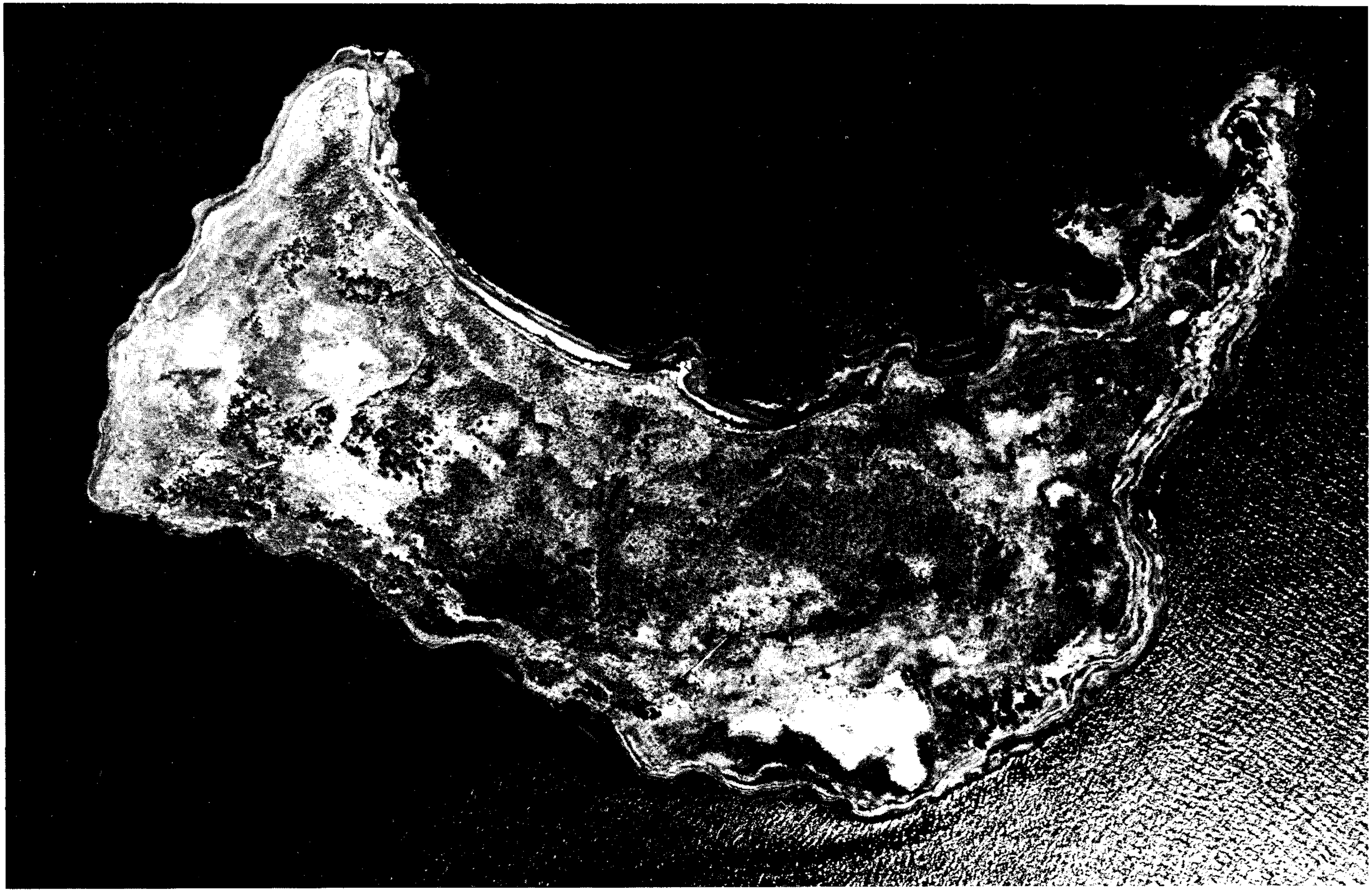


Figure D3. Aerial View of Study Island A35

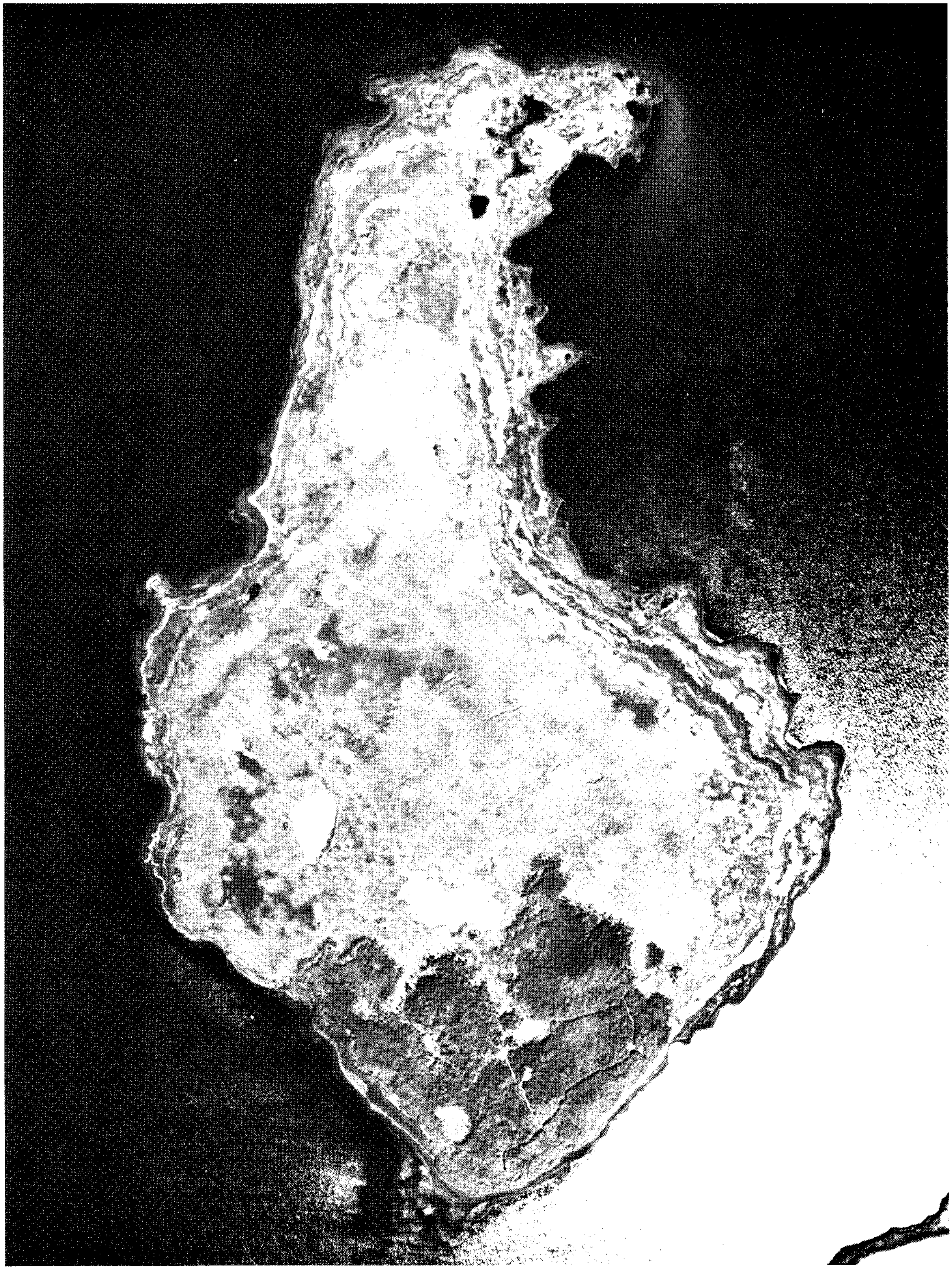


Figure D4. Aerial view of Study Island A43a

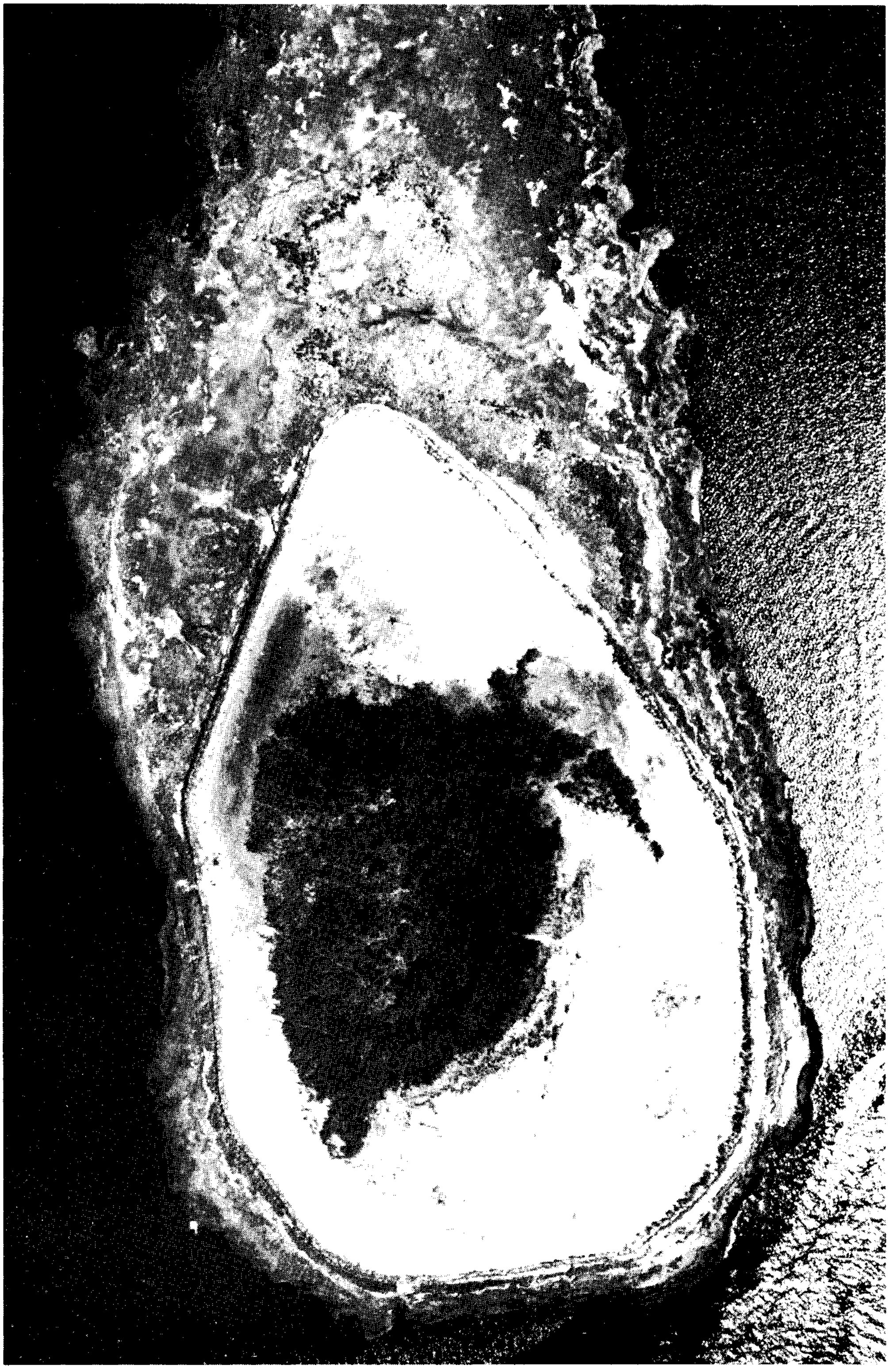


Figure D5. Aerial view of Study Island 45A

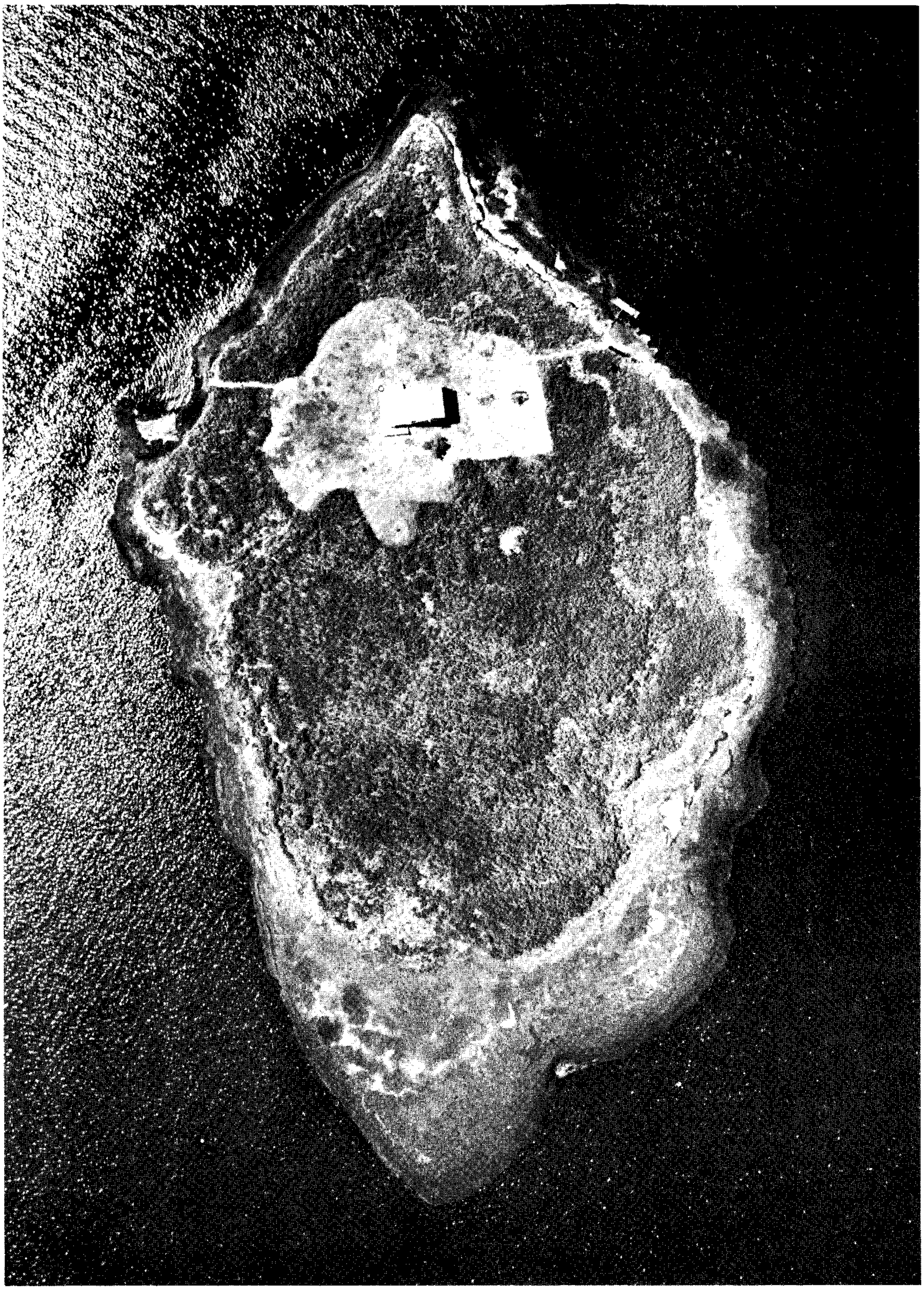


Figure D6. Aerial view of Study Island 45B

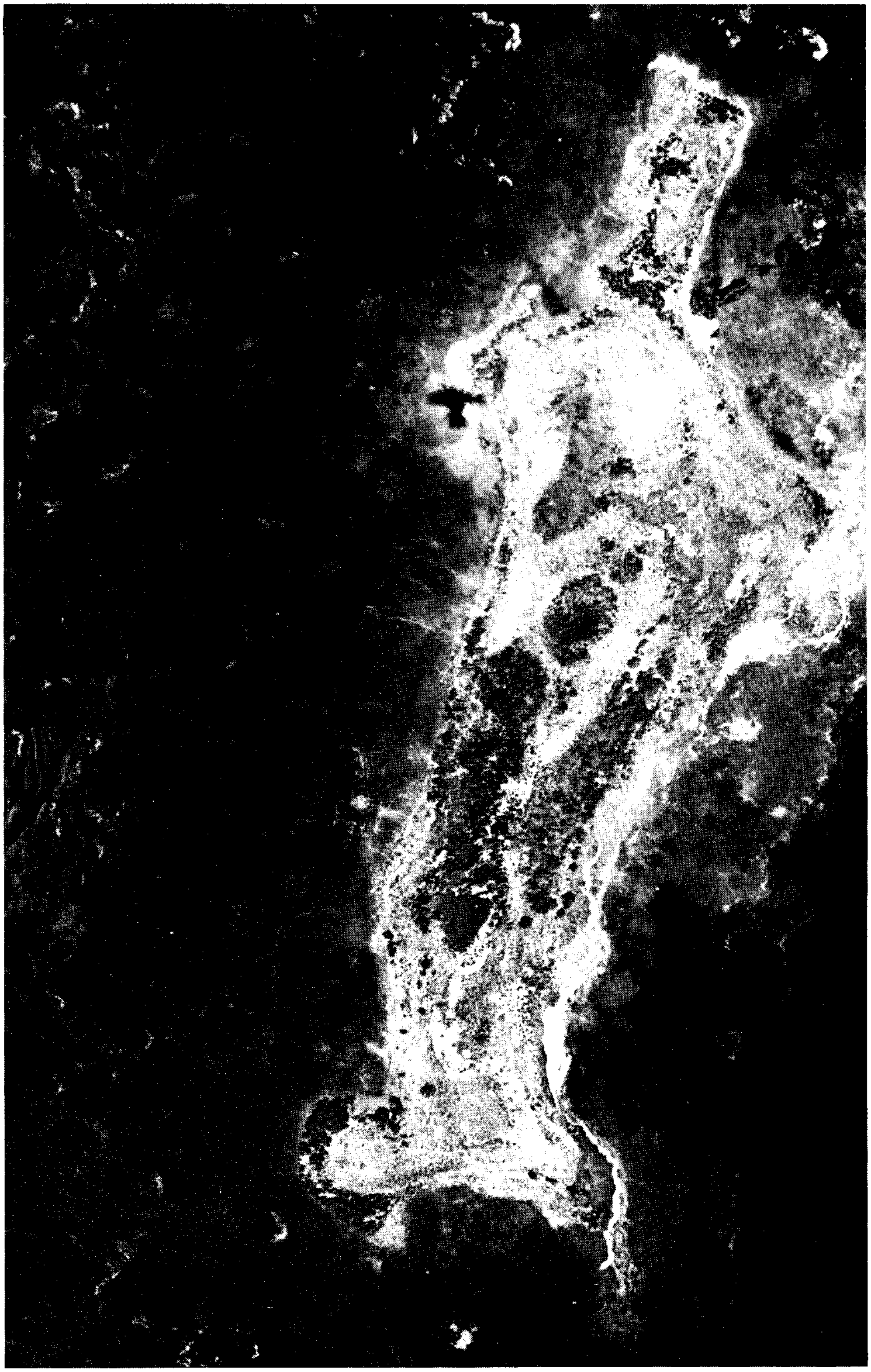


Figure D7. Aerial view of Study Island X27

Figure D8. Aerial view of Study Island 51B

Figure D9. Aerial view of Study Island A61c

Figure D10. Aerial view of Study Island A59a

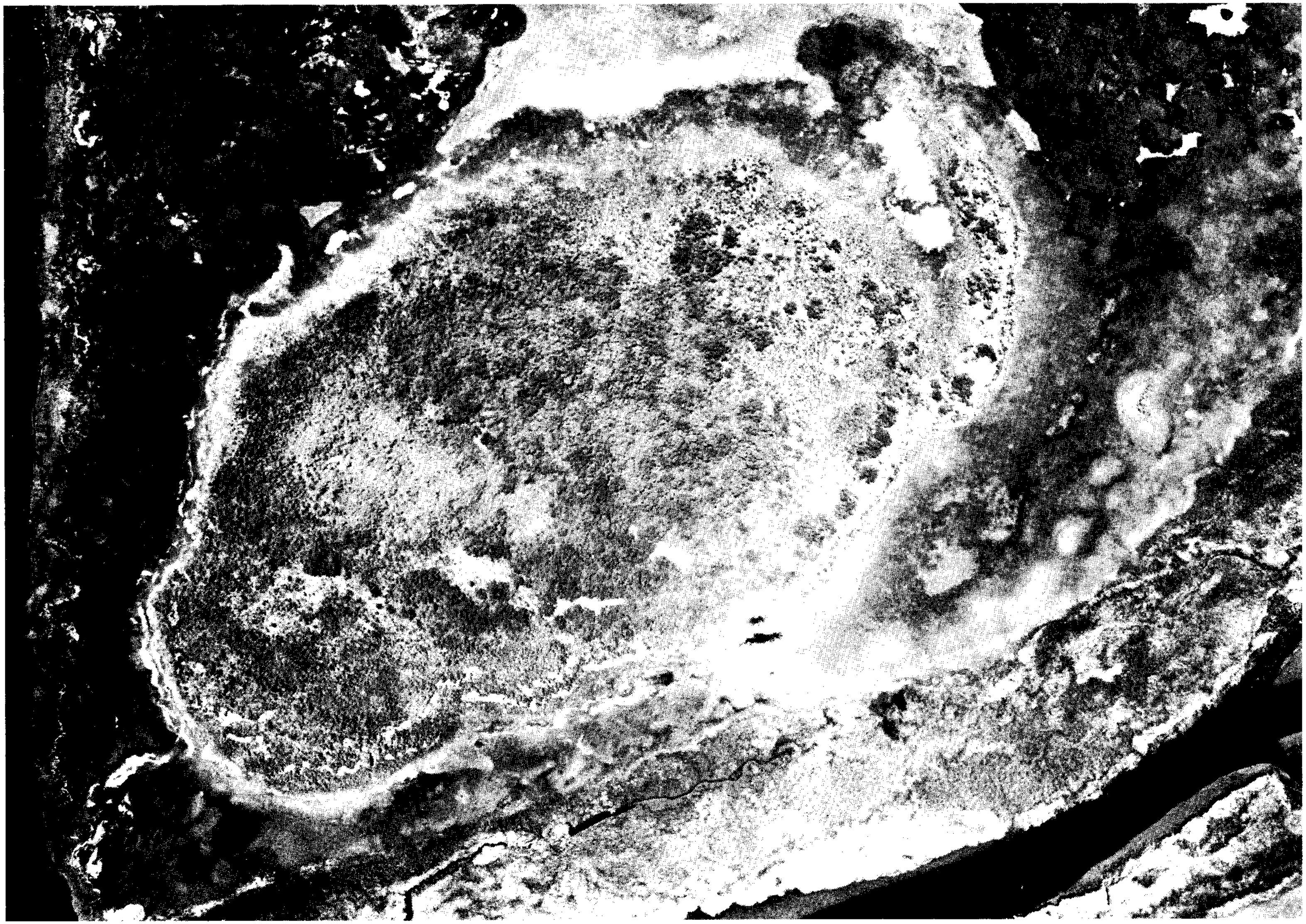


Figure D11. Aerial view of Study Island 85dmi

Figure D12. Aerial view of Study Island 85 South

Figure D13. Aerial view of Study Island 98A

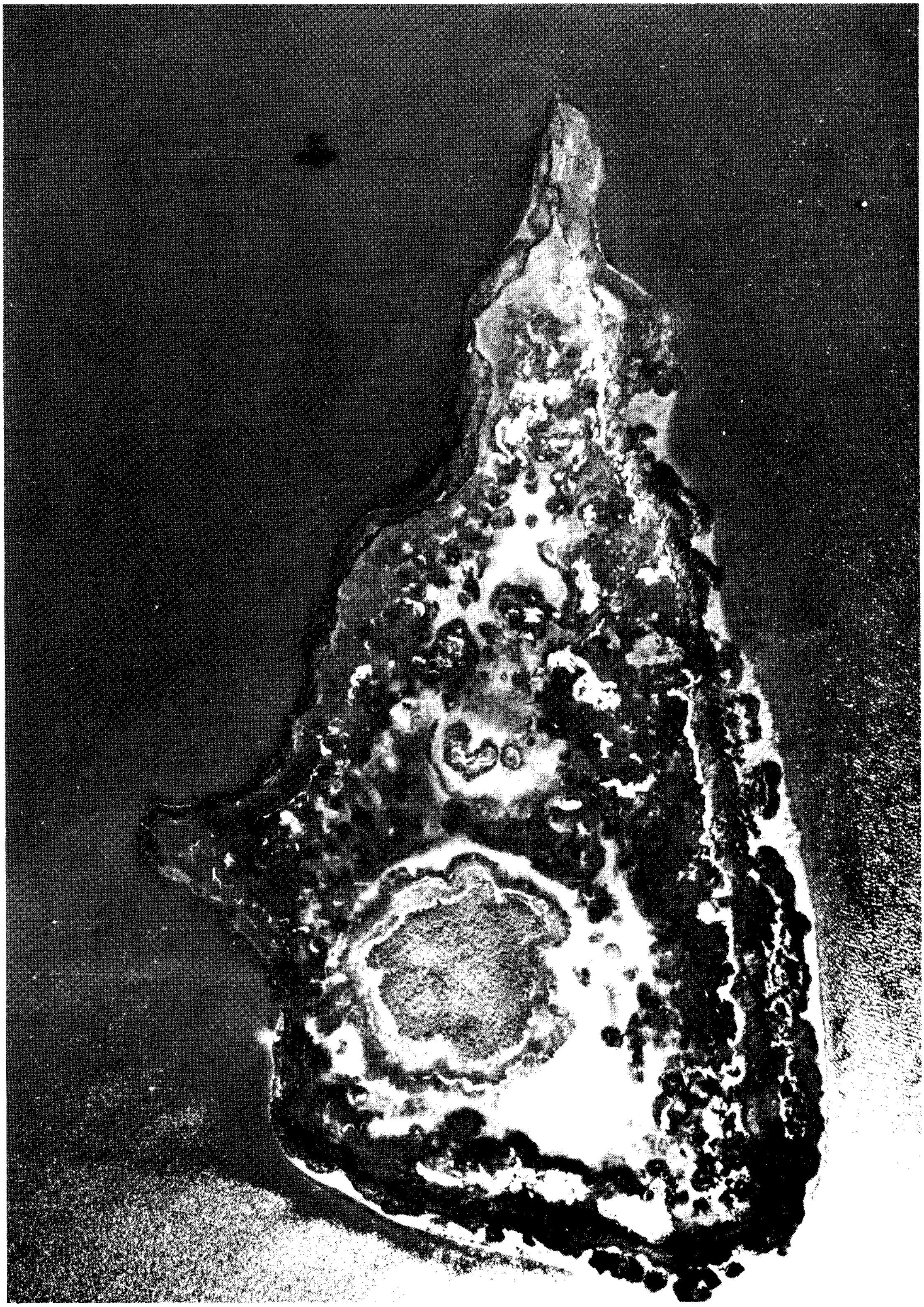


Figure D14. Aerial view of Study Island 108B

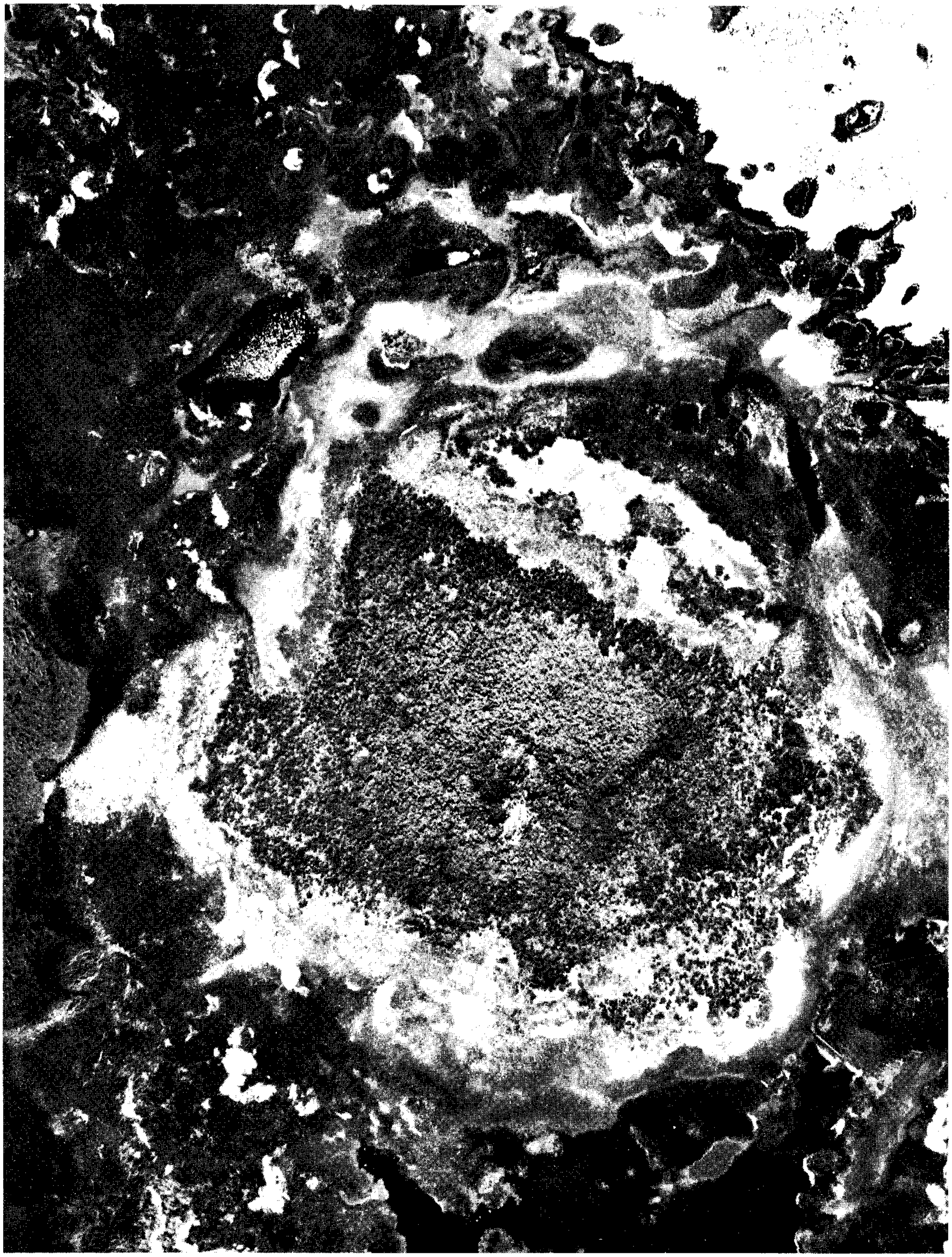


Figure D15. Aerial view of Study Island 98B North

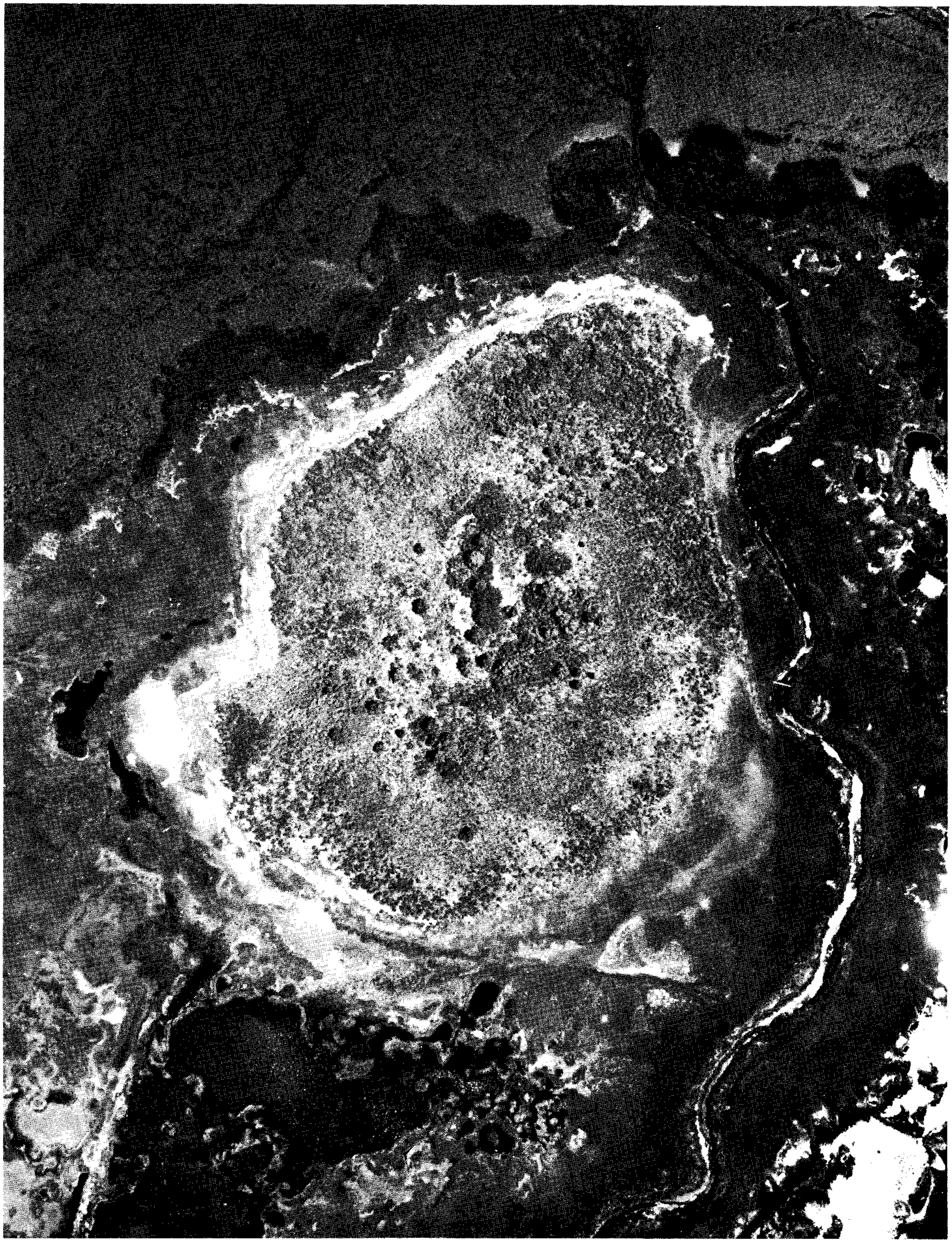


Figure D16. Aerial view of Study Island 98B South

Figure D17. Aerial view of Study Island 78B South

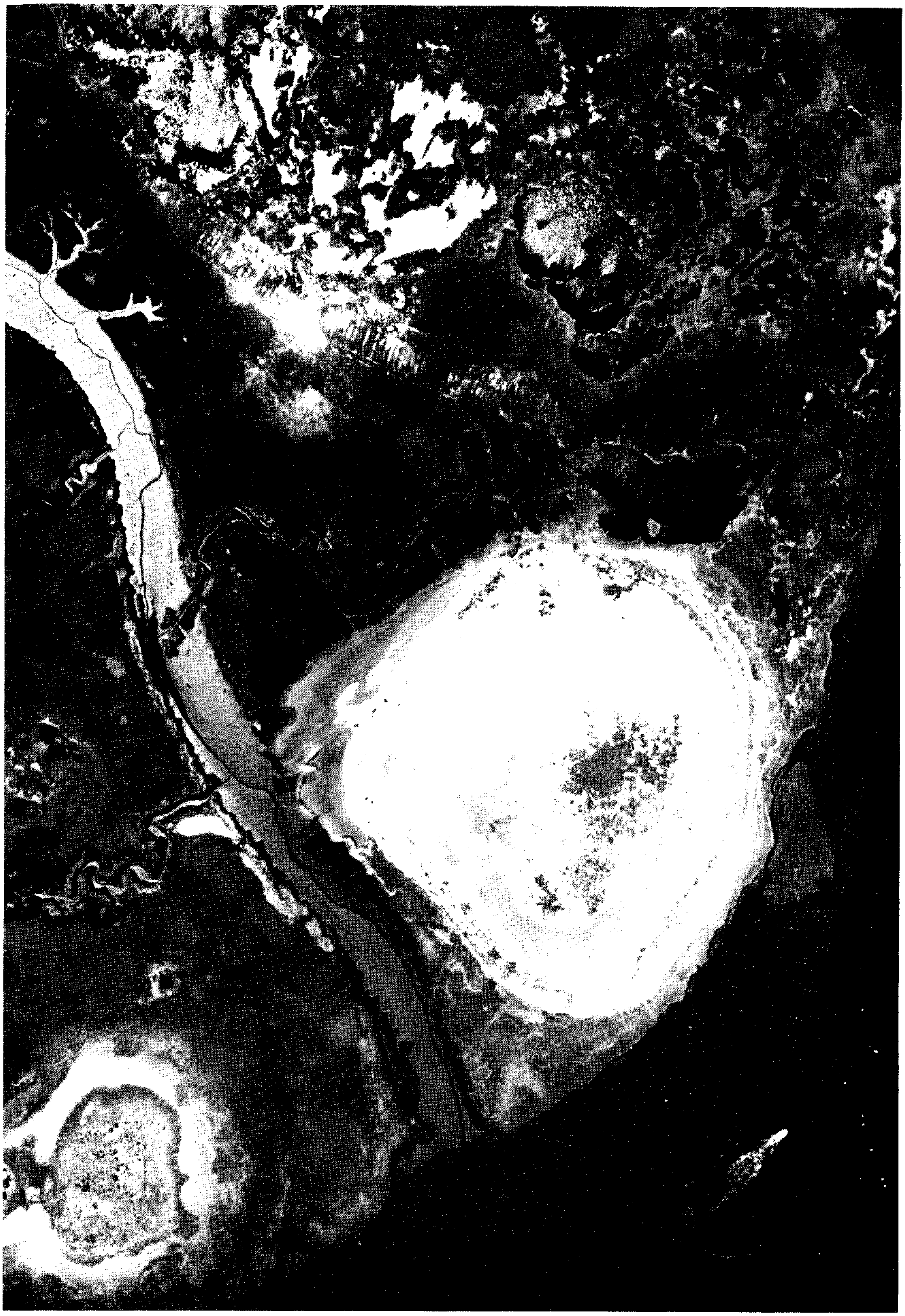


Figure D18. Aerial view of Study Island 103

Figure D19. Aerial view of Study Island 85C

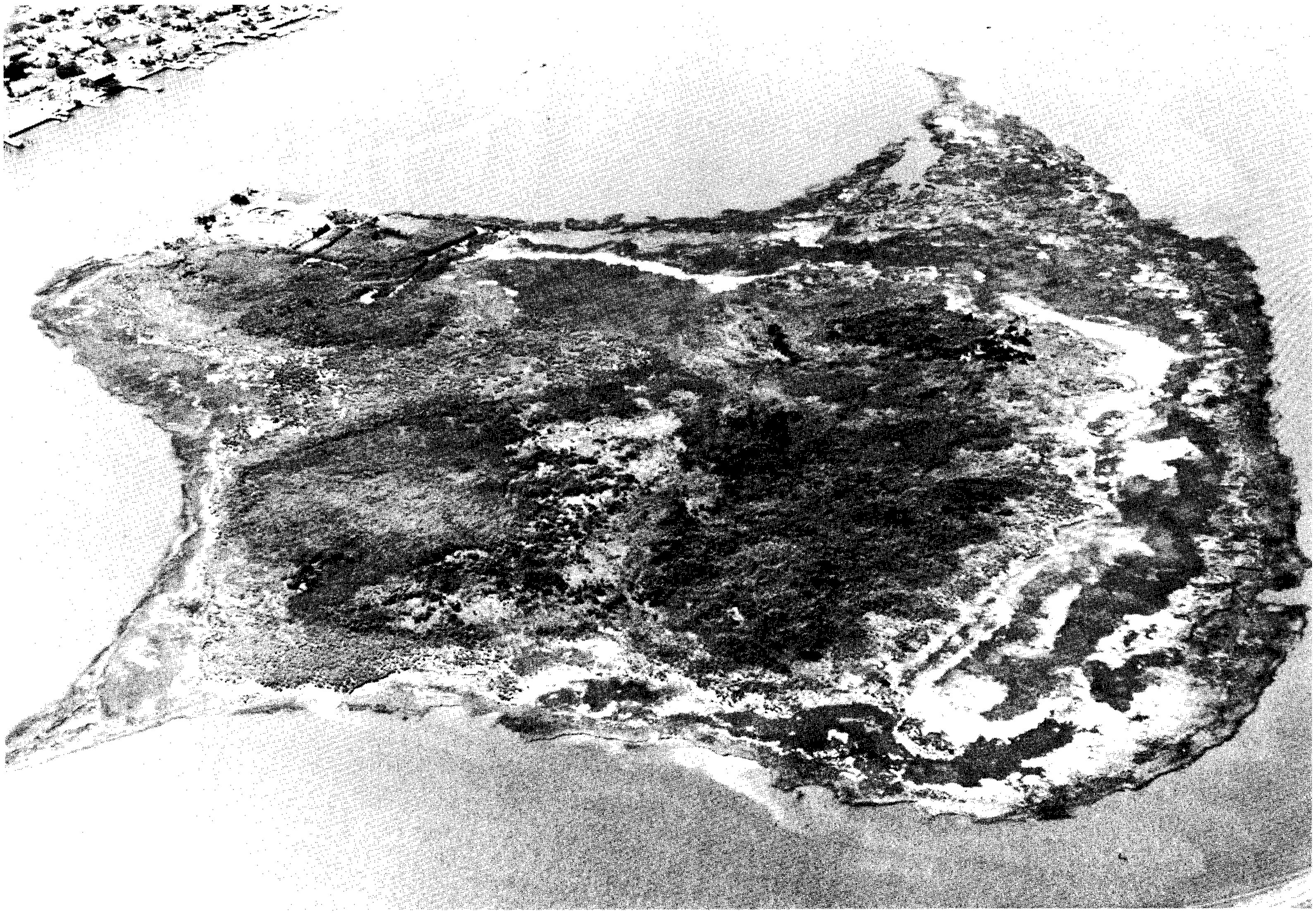


Figure D20. Aerial view of Study Island 109

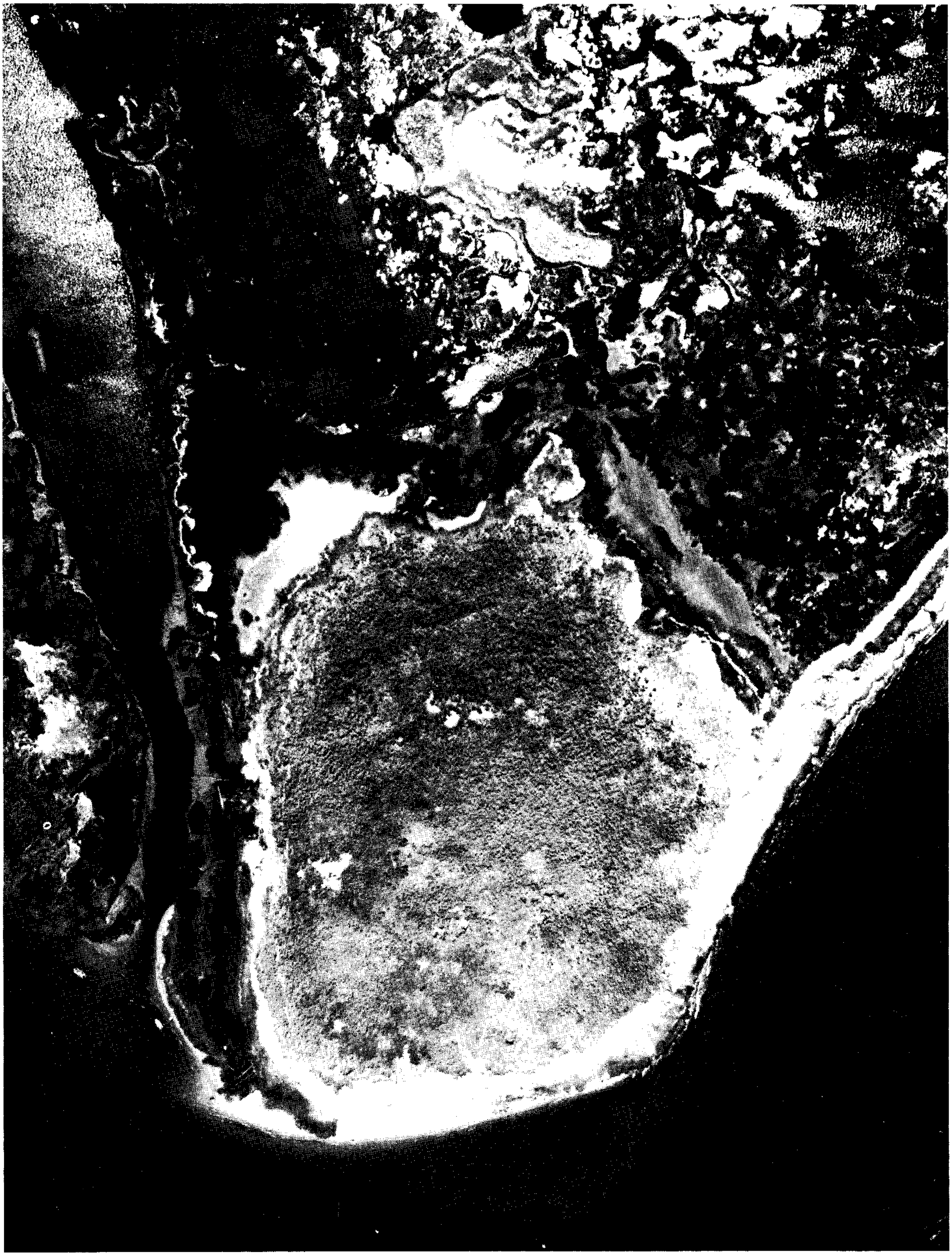


Figure D21. Aerial view of Study Island 109 South

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Buckley, Francine G

Use of dredged material islands by colonial seabirds and wading birds in New Jersey / by Francine G. Buckley, Cheryl A. McCaffrey, Manomet Bird Observatory, Manomet, Mass. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.

157, [48] p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; D-78-1)

Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under Contract No. DACW39-76-C-0166 (DMRP Work Unit No. 4F01D)

Appendices A and B on microfiche in pocket.

Literature cited: p. 154-157.

1. Birds. 2. Dredged material. 3. Islands (Landforms). 4. New Jersey. 5. Seabirds. 6. Shore birds. I. McCaffrey, Cheryl A., joint author. II. Manomet Bird Observatory. III. United States. Army. Corps of Engineers. IV. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; D-78-1.

TA7.W34 no.D-78-1